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SOME ENTOMOLOGICAL ASPECTS OF THE SLASH DISPOSAL PROBLEM[1]

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While the practice of forestry in the United States consisted primarily of fire fighting and fire protection, the question of slash disposal received consideration from but one angle—that of fire protection. The fire fighting forester saw in slash a menace which not only increased the probability of starting fires, but which greatly increased the danger and difficulty of fire fighting. He saw in slash an enemy without a single saving grace. Convinced that it must be disposed of, he recommended that it be burned wherever possible. And under the conditions in which he was working we must all admit that he followed the best possible course of procedure.

During the last few years, however, conditions have been obviously changing. Protection from fire is just as important as ever, but we are beginning to hear the voice of the silviculturist who points out the fact that we are burning up valuable humus in our slash piles. Moreover we hear some lumbermen saying that they would rather put on an intensive fire patrol for a few years after logging than to carry out the rather expensive operation of burning slash. Even experienced fire fighters are sometimes heard to say that well piled slash is not such a menace as it was once considered to be. Thus the question of slash disposal is open again. This time the problem is being attacked from all sides rather than from a single point of view, and only by thus attacking it from many angles can we ever hope to reach the correct solution.

[1] Published with the approval of the Director as Paper No. 314 of the Journal Series of the Minnesota Agricultural Experiment Station.

Entomologists, without exception, have recommended the burning of slash, stating that in this way the breeding places of many injurious forest insects will be destroyed and the number of these pests will thus be materially reduced. This advice has been used more than once by foresters as a supplementary argument to convert some "doubting Thomas" to slash burning. Usually entomologists have couched their recommendations regarding slash burning in such positive terms that no doubt has been left in the mind of the layman as to the efficacy of this control measure. From their emphatic character it has naturally been assumed by many that these statements are based upon a firm foundation of experimental evidence supplemented by accurate general observations. Search through forest entomological literature, however, fails to reveal that such is the case. The positive attitude of many entomologists on this proposition probably had its origin in Europe and is only supported in this country by scattered and somewhat uncertain observations.

For instance, a general observation of this sort was made in connection with the present outbreak of the spruce bud-worm, *Tortrix fumiferana* Clem., in eastern Canada. Following the attack of the bud-worm many of the injured Canada balsam trees were killed by the secondary attack of the balsam bark-beetle, *Pityokteines sparsus* Lec. This secondary injury was greater in regions where logging was going on than in localities remote from timber operations. This indicates that probably the presence of an abundance of slash brought about an increase in the abundance of the beetles, which in turn resulted in the death by bark-beetle attack of a larger proportion of the injured trees in these places than in regions where slash was absent. Even if we grant that this observation is accurate and that the theoretical explanation is correct, are we justified in assuming that slash burning will obviate this condition?

In many other cases it has been noticed by entomologists, and the observation is undoubtedly correct, that wood boring insects are more numerous in areas where slash provides an abundance of breeding places. From this it is assumed that these insects constitute a distinct menace to the forest in these localities. Doubtless this is true in some cases, but there are no available data to show that slash burning will actually reduce the abundance of these injurious species. A pertinent question which might well be asked in this connection is: how much material suitable for insect breeding remains after the ordinary slash burning operation? No data answering this question are available.

Apparently the entomological recommendation to burn slash is based upon general observations such as those cited above, but whether or not slash burning is advisable as a means of insect control can only be proved by special study and not by hit or miss observation. The study set forth in this paper was undertaken to establish or disprove the efficacy of slash burning as a means of forest insect control in the Northeastern forests. Naturally the results are not final, but all the evidence so far collected seems to establish the fact that slash properly piled is less of a menace, so far as insects are concerned, than the remains of slash left after the ordinary burning operation. Cases will doubtless arise where slash burning may be necessary to control some particular pest, therefore the above statement is not intended to apply to such specific instances.

METHODS USED IN COLLECTING DATA

This paper is based upon careful studies of unburned and burned slash in Itasca Park, Minnesota, and is supplemented by general observations in other places in Minnesota, Eastern Canada, and New York State. The intensive work was done on pine slash: Jack pine, *Pinus divaricata;* Norway pine, *Pinus resinosa* Aiton; and white pine, *Pinus strobus* Linn. Less extensive studies were made on the slash of Canada balsam, *Abies balsamea* Linn., and black spruce, *Picea mariana* Britton, Sterns, and Poggenberg. This work was further supplemented by studies of the physical factors influencing the activities of insects in logs, which have been under way since 1920. In the experiments with these physical factors, logs were placed under different conditions of light and moisture and record was kept of insect infestation and insect activity under known conditions. These experiments have furnished a background of supplementary evidence for data gathered from the specific study of slash piles.[2]

The burned slash area was studied during the summer of 1920 on land which had been logged during the winter of 1918-19. The burning had been carried on under unusually careful supervision and represented what is considered to be satisfactory slash burning.

The work with unburned slash was conducted during the summer of 1921 on slash cut and piled during the winter of 1920-21. This slash was from an improvement cutting and the piles were located in

[2] This work has been reported in part in an article entitled "Factors Influencing Subcortical Temperature in Logs." Fifteenth report of the State Entomologist, Minnesota.

a variety of conditions varying from full sun to a condition of quite heavy shade. Each pile studied was pulled apart and the kind and extent of insect infestation in pieces from the top, the middle, and the bottom were recorded in each case.

In the light of previous observations, it seems reasonable to believe that the results from this study, while they cannot be considered as absolutely conclusive, are representative of conditions normally found in Northeastern forests.

INSECTS CONCERNED IN THIS PROBLEM

By no means all the insects commonly found working in slash are injurious. Quite the contrary is the case with many species such as those which confine their activities entirely to dead wood. Other insects such as Hylurgops, some species of Pissodes, and Mohammus which are found commonly in slash attack freshly cut wood but are unable to maintain themselves where the flow of sap has not ceased. All these insects are beneficial in that they aid materially in the rapid disintegration of the slash. For that matter, all the insects working in a slash pile do much to hasten disintegration both by their own activities and by opening the way for fungus infection. In the prosecution of the present work many specimens have been collected which demonstrate clearly that rot fungi frequently gain entrance into the wood through insect tunnels.

Some insect species which breed commonly in slash may, however, be potentially injurious, and it is these forms that hold our chief interest in this study. All of the potentially injurious insects which breed in slash require fresh cambium during at least a part of their developmental period and are therefore green-wood insects. Such insects as these may under certain conditions attack and kill healthy standing timber, thus becoming injurious forest pests.

It is not necessarily true, however, that all insects occurring commonly in slash which require green wood for their development are potentially injurious to standing timber. Some of them are never able to attack a healthy standing tree under any circumstances, others are able to kill a few healthy trees under certain circumstances, while still others may become epidemic. As an example of the first group, which never kills healthy trees, *Pityogenes hopkinsi* Sw. may be cited. *Ips pini* Say may serve as an example of an insect which occasionally kills a few trees. *Polygraphus rufipennis* Ky. and *Dendroctonus piceoperda* Hopk. are said to occasionally become epidemic.

The ability to cope with the flow of sap or resin is one of the most important factors determining whether or not an insect can attack a living tree. Of all the bark-beetles, the Dendroctonus beetles seem to be better able to cope with resin than any other group; therefore they most often become epidemic. Such species as *Ips pini* Say is capable of enduring resin to a less degree, therefore this species only kills living trees when it occurs in such large numbers that the attacked tree is quickly girdled, thus stopping quickly the flow of resin. Such species as *Pityogenes hopkinsi* Sw. are still less able to cope with resin and therefore never attack healthy trees. In this study we are concerned primarily with the potentially injurious species.

EFFECT OF SLASH BURNING UPON POTENTIALLY INJURIOUS INSECTS

Although the statement of entomologists to the effect that slash frequently furnishes a breeding place for many dangerous forest insects seems to be based upon comparatively little evidence, let us for the sake of argument admit the probability that many insects breeding in slash are potentially injurious, especially when they occur in enormous numbers, and that this condition frequently occurs. In other words, let us assume that the danger to standing timber from slash left in the woods is as great as the most enthusiastic exponent of slash burning would like us to think. Then let us see if slash burning will actually do what is claimed for it.

One of the first questions to consider is what part of the slash furnishes the best breeding ground for insects. Is it the small material under an inch in diameter or is it the larger branches, tops, and broken logs? What role do the stumps play? Since we know that all the potentially injurious slash insects are green cambium borers during some part of their life cycle, it is obvious that the small parts of the slash, which dry out quickly, are suitable as breeding places for such insects during a much shorter period of time than the larger parts with their thicker covering of bark. Moisture is a very important factor. We also know, from previous work, that very high subcortical temperatures occur on the upper side of thin barked logs and branches often making these parts uninhabitable. Thus by a combination of heat, lack of moisture, and other factors, small branches under an inch in diameter exposed to full sunlight are usually very unfavorable to insect development. The few insects found breeding in this location are usually insects able to withstand comparatively dry conditions such as some species of Pityogenes and Chrysobothris, which cannot be re-

garded as a serious menace to healthy standing timber. As the diameter of the pieces increases the thickness of the bark increases, and the proportion of the branch subject to high temperature becomes smaller, thus the proportion of the branch suitable for the maintenance of insect life is greater. In the bottom of slash piles opposite conditions of temperature and moisture prevail. In such locations the sap in the cambium region ferments and becomes distasteful to the insects which require fresh cambium. Also the temperature in such a location is usually quite low, thus reducing the rate of larval development. These conditions apply to all parts of the slash at the bottom of the pile regardless of size. As a result of these facts, we find an entirely different set of insect inhabitants in such places, none of which have the ability to produce injury to healthy trees. Examples of such insects are Hylurgops, some species of Pissodes of the secondary type, moisture loving Cerambycidae, fungus beetles, and the like.

From the foregoing discussion it is evident that the parts of the slash suitable as breeding places for potentially injurious insects are limited to those parts which do not dry out quickly, where extremely high or low temperatures do not occur, and where very moist conditions with the resulting fermentation of the sap do not prevail. Such conditions are found most abundantly in the larger branches, tops, and broken logs when these parts are not heavily shaded.

It is beyond the scope of the present paper to list all the insects found under each of these conditions, but it seems desirable to list according to environment some of the most common types, found in the course of this study. There are some differences between the different species of slash, but in general the results are as follows:

Branches under one inch in diameter.

1. In full sun.
   - (*a.*) Upper surface.
     - Uninfested or with a few poorly developed Buprestid larvæ. No species injurious to healthy trees.
   - (*b.*) Lower surface.
     - Pityogenes is here the most common bark-beetle genus.
     - Species of Ips occur occasionally, seldom any brood.
     - Cerambycid larvæ are occasionally found.
     - Burdestidæ are often abundant.
     - Very few of the insects in this group are able to injure healthy trees and then at most very occasionally.
2. In shade but dry.
   - Species of Ips are often abundant.
   - Species of Pityogenes are often abundant.
   - Cerambycidae such as Monohammus are common.
   - Potentially injurious forms somewhat more frequent but not abundant.

3. In dark moist condition.
    Pissodes of the secondary type.
    Hylurgopes.
    Cerambycidae.
    Pyrochroidae.
    Melandryidae.
    Elateridae.
    All of these insects are harmless or actually beneficial.

Comparatively thin barked branches over one inch in diameter.

1. In full sun.
    (*a.*) Upper surface.
        Usually lightly infested with Buprestidae.
        Occasionally small bark beetles capable of withstanding dry, hot conditions such as Pityogenes.
        No species injurious to healthy trees.
    (*b.*) Lower surface.
        Usually freely attacked by some bark-beetles such as Ips and Pityogenes.
        Cerambycids such as Monohammus.
        Buprestid larvæ often present.
        Few potentially injurious insects.
2. Under shaded conditions almost the same types are found in large and in small branches.

Thick barked branches and tops.

1. In full sun.
    (*a.*) Upper surface.
        Both harmless and potentially injurious bark beetles such as species of Ips are occasionally found under very thick bark.
        Cerambycidae are usually rare.
        Buprestidae usually abundant.
        Few potentially injurious species.
    (*b.*) Lateral surfaces.
        Here occur secondary Cerambycidae, like Monohammus.
        Buprestidae, such as Chrysobothris, and Chalcophora.
        The most common bark beetles are species of Ips, Polygraphus, and more occasionally Dendroctonus—all of which may be potentially injurious.
        This location usually contains the greatest number of species which may be potentially injurious to healthy trees.
    (*c.*) Lower surface.
        Here the insects represent the same groups as found under dark, moist conditions in smaller branches.

Stumps.

Dendroctonus beetles which are potentially injurious often occur in this location.

We also find Ips species which may become sporadically injurious to living trees.
Also Cerambycidae and Buprestidae.
On the shady side, particularly near the ground, Hylurgops and other moisture loving forms are often found.
Here are found the greatest number of potentially injurious species.

It is evident from this study that the most injurious insects are found most abundantly in large branches, tops, broken logs and stumps where moisture and other conditions are favorable for their development.

As might be naturally expected, we find that those insects which are potentially injurious to healthy trees breed most abundantly in those parts of the slash in which conditions are most like the conditions existing in the living tree. Conditions within the fresh cut stump are closely comparable to conditions in the living tree. These parts become unfavorable for the insects when placed under cool moist conditions such as usually exists at the bottom of a slash pile, where very few if any harmful forms can maintain themselves. Thus if the larger pieces of slash and the stump can be buried under the smaller material the available breeding places for injurious forest insects would thus be materially reduced.

These facts are further illustrated by the following Tables 1 and 2 which show the distribution of a few typical slash insects as actually observed in the field. Tables 3 and 4 illustrate the infestation of logs lying in a north and south direction under controlled light conditions.

TABLE 1.—*Distribution of Typical Slash Bark Beetles in Slash Piles Exposed to Full Sun.*

Insect	Surface of piece	Average number of nuptial chambers per 12 square inches		
		Top of pile	Middle of pile	Bottom of pile
Pityogenes	Upper	0.06	3.0	0.2
	Lower	2.8	3.0	0.0
Ips	Upper	0.0	3.5	3.0
	Lower	1.0	3.5	1.0
Hylurgops	Upper	0.0	0.0	[a]1.0
	Lower	0.0	0.0	[a]3.0

[a] Egg gallery.

TABLE 2.—*Distribution of Other Larvæ in Slash Piles in Full Sun.*

Insect	Surface of piece	Average number of larvæ per 12 square inches		
		Top of pile	Middle of pile	Bottom of pile
Pissodes	Upper	0.0	0.0	2.0
	Lower	0.0	0.0	6.0
Monohammus	Upper	0.0	1.75	0.2
	Lower	0.01	1.75	0.0
Other Cerambycidae	Upper	0.0	2.0	4.0
	Lower	0.2	2.0	2.0
Buprestidae	Upper	2.0	0.0	0.0
	Lower	3.0	0.0	0.0

MATERIAL REMAINING AFTER SLASH BURNING

As has been previously pointed out the operation of slash burning is performed primarily to reduce the fire hazard. The fine materials being the most inflammable part of the slash naturally receive the most attention. Since the larger pieces are difficult to burn, and since their presence in the woods does not materially increase the danger of fire, these parts are ordinarily neglected. For this reason after burning of the slash a very large proportion of this large diameter material is left lying on the ground, most of it still uncharred and thus in a suitable condition for insect attack.

It should be mentioned here that it is not necessary to burn wood completely in order to prevent the breeding of injurious insects. Thorough charring of the bark is sufficient, but unless the piece is entirely within the fire thorough charring cannot be accomplished. It is not at all uncommon to observe large branches which have been partly burned with the unscorched parts filled with insect brood. One case was observed where Monohammus and bark beetles had emerged from a piece of norway pine six inches in diameter within six inches of where it had been severely scorched in a slash fire. Even if it were practically possible to destroy all slash including the large tops, broken logs and butts, we must not forget that the stumps would still be available as breeding places for insects. It is customary to leave the stumps untouched in spite of the fact that they furnish the best breeding place of all for potentially injurious species. Therefore, in order to be effective as a means of insect control, all of the large branches, tops, broken logs and butts should be thoroughly scorched by the fire, and

TABLE 3.—*Distribution of Bark-Beetles in Logs Under Controlled Conditions. (Unit area 144 square inches of surface.)*

Species of log	Full sun				One-third shade				One-half shade				Three-fourths shade			
	Top	West	East	Bottom	Top	West	East	Bottom	Top	West	East	Bottom	Top	West	East	Bottom
Norway pine......	29	92	105	58	59	78	84	46	40	48	43	39	88	92	65	48
White pine......	0	55	39	41	14	33	34	37	8	70	77	45	67	63	50	41
Jack pine......	2	63	37	32	7	13	29	27	25	11	16	14	45	43	45	38
Spruce	0	21	18	32	1	7	9	14	10	35	52	38	31	23	66	72

TABLE 4.—*Distribution of Monohammus in Logs Under Controlled Conditions. (Unit area 144 square inches of surface.)*

Species of log	Full sun				One-third shade				One-half shade				Three-fourths shade			
	Top	West	East	Bottom	Top	West	East	Bottom	Top	West	East	Bottom	Top	West	East	Bottom
Norway pine......	1	4	1	5	1	2	2	3	1	3	4	1	1	3	2	1
White pine......	1	7	5	6	2	7	5	4	5	10	11	12	2	6	4	2
Jack pine......	2	3	1	3	0	4	4	2	1	1	1	2	2	2	1	1
Spruce	0	3	2	5	2	6	11	1	0	6	4	1	1	3	1	1

every effort should be made to build the slash fires over the stumps so that as many as practicable be scorched and rendered unsusceptible to insect attack. This would add materially to the cost of slash burning.

On the other hand all the data upon which this paper is based go to prove that green wood when lying in heavily shaded damp conditions is attacked only by purely secondary or entirely harmless species. Therefore, if the parts of the slash most favorable as breeding places be covered with less favorable parts they become in turn unsuited for the development of insects injurious to standing timber.

RECOMMENDATIONS AND CONCLUSIONS

From the data accumulated during the course of this study supplemented by observations of a more general nature, we are forced to conclude that slash burning under Northeastern forest conditions is not as effective a factor in forest insect control as has been generally believed. The reasons for this conclusion are as follows:

1. Very few truly primary insects are found breeding in slash.
2. The normally harmless species which occasionally appear in such large numbers that they may become temporarily injurious, breed in slash, but usually the larger materials are more suited to their needs than the small branches.
3. In addition to the slash, the stumps furnish ideal breeding places for insects. In fact the stumps are better adapted as breeding places for the most injurious species than any part of the slash, because conditions within a fresh cut stump approaches most nearly the conditions in a living tree.
4. In practically no slash burning operation is any effort made to char the stumps and ordinarily only that part of the larger material used for weighting down the pile is burned. As a result a very large proportion of the wood suitable for insect breeding remains after the slash is burned.
5. Pieces lying near the ground in the bottom of slash piles are entirely unsuitable as food for injurious insects and only serve as a breeding place for purely harmless or beneficial species.

In the light of these findings it appears that in Northeastern forests burning is not the best method of handling slash for insect control. It is much more effective to leave the slash piled in such a way that most of the large diameter material is laid close to the ground and covered with the finer parts of the slash. As far as possible the piles should be built over stumps, thus reducing still more possible breeding places of potentially dangerous forest insects. Therefore from the evidence herein presented a general policy of slash burning cannot be recommended as an effective method of forest insect control. Let us instead of burning substitute better methods of piling slash to prevent the multiplication of harmful insects.

BRANCH ORDERS AND TOLERANCE

By F. L. DuMond

Contribution from the Yale School of Forestry, No. XVIII.

In 1907 Weisner[1] investigated the number of branch orders in crowns of various species of trees growing in the vicinity of Vienna, Austria. The object in view was to ascertain what relation, if any, existed between the maximum number of branch orders present in the species investigated and their tolerance. In Table 1, the species studied by Wiesner are arranged in accordance with the maximum number of branch orders found in each.

Table 1.—*Common Forest Trees Grown in Europe, Arranged in Accordance with the Maximum Number of Branch Orders.*

Species	Maximum number of branch orders	Species	Maximum number of branch orders
Larix (Larch)	3–4	Quercus (Oak)	6
Ginko (Ginko)	4	Robinia (Black locust)	7
Gleditsia (Honey locust)	5	Ulmus (Elm)	7
Populus (Poplar)	5	Fraxinus (Ash)	7
Picea (Spruce)	5	Carpinus (Hornbeam)	8
Pinus laricio (Austrian pine)	5	Fagus (Beech)	8
Betula (Birch)	5	Taxus (Yew)	8

Zon and Graves[2] in commenting on this study by Wiesner state: "In these lists species having the smallest number of branch orders must be classed as intolerant, and those with the largest number of branch orders as distinctly tolerant. The only apparent exception is spruce, which by this method, would be grouped under the intolerant species. The small number of branch orders found in spruce, may not, however, be due entirely to light, since many of the smaller branches of old spruce trees are bitten off by animals, especially squirrels. The interference by animals, insects and other agencies, with the successive branch formations in a tree constitutes a weak point in this method of determining tolerance; moreover, the method is, of course, altogether too complicated for practical use." It appears to the writer that Wiesner's scale of tolerance based on the maximum

[1] Wiesner, Julius. Der Lichtgenuss der Pflanzen. Leipzig, 1907.

[2] Zon, Raphael, and Graves, Henry S. Light in Relation to Tree Growth. U. S. D. A. Bul. 92.

number of branch orders, places black locust far too low in the list, as it is usually classed as an intolerant species.

The present study of the maximum number of branch orders in twenty-two of the most important tree species of southern Connecticut was undertaken in an effort to ascertain to what extent the method of maximum branch orders first suggested by Wiesner can be relied upon in developing local scales of tolerance. From ten to forty individual specimens of each of the species studied were examined, including trees of different ages and sizes, growing in the open and in stands and on various sites. The variations in the number of branch orders within the species depending upon the position of the branch in the crown, the size and age of the tree, whether grown in the open or in closed stands or on sites of different quality, are brought out in the following tables.

The relatively few branch orders in all species, varying from three to eight, make the comparison of a large number of species of somewhat uncertain value. This is particularly so in that 70 per cent of the species studied have maximum branch orders of four or five, yet they vary widely in tolerance. It has been possible to express the average maximum number of branch orders for each species in units and hundredths by adding the maximum number of orders found in each individual species and dividing by the total number. This method permits a more useful tabulation and closer comparison than when the branch orders are expressed in whole numbers.

As the study developed it became desirable not only to compare the number of branch orders with tolerance, but also with the size of the ultimate twigs and the area of the leaf surface.

It has recently been emphasized by Toumey,[3] Burns,[4] and others that tolerance as interpreted by most foresters is not a true measure of light requirement although it is usually defined as the measure of the capacity of a tree to bear shade.[5] The reason for this is that the usual interpretation of a tree's tolerance is expressed in its vigor and development under a forest canopy. Thus if a given species exhibits greater vigor and more robust growth than another under the same density of canopy it is listed as of greater tolerance. It is obvious, however, that more factors than light act upon and affect the vigor and

[3] Toumey, J. W. The Relation of Gray Birch to the Regeneration of White Pine. Journal of Forestry, Vol. XVII, No. 1.

[4] Burns, G. P. Studies in Tolerance of New England Forest Trees. Ver. Agr. Exp. Sta. Bul. 193.

[5] Forest Terminology. Journal of Forestry, Vol. XV, No. 1.

growth of trees growing under a more or less complete canopy of overstanding trees. Root competition as pointed out by Fricks [6] and Toumey [7] and others may play quite as important a role as light in determining vigor and growth under canopy. Although in theory we say that tolerance is the measure of the capacity of a tree to bear shade, in practice it is the measure of a tree to grow and develop under other trees which not only shade it but which compete with it for soil space in which the roots can spread and secure moisture and nutrients.

In this study tolerance expresses the capacity of a species to develop and reproduce under an overwood.

BRANCH ORDERS

Theoretically the number of branch orders possible in a tree is one less than the age of the tree.[8] It is usually the case that branches arise on the ascending axis during the second year, buds on these branches give rise to branches of the second order the following year, and so on during the life of the tree. As the development of branch orders ordinarily takes place, however, the above is far from being the case. As the tree develops, the continued succession of higher branch orders with the retention of all is inhibited due to the shading effect on the interior by the periphery of the crown and its mantle of leaves. The earlier branch orders disappear due to shading and later orders are developed. Theoretically at least, other things being equal, the number of the branch orders depends upon the intensity of the light which they receive and their degree of resistance to shading.

The maximum number of branch orders present varies with the species.—Species which have the greatest capacity for growth and development in diminished light, provided the conditions under which they exist are equal, produce and retain at a given time the greatest number of branch orders. As will be shown later, however, the size and form of leaves and the size of the ultimate twigs, as well as the age of the tree and the site upon which it grows, directly influence the number of branch orders. Thus, a tree with large leaves produced at the ends of the twigs, as in the umbrella tree, permits but little light

[6] Fricke, Karl. "Licht und Schattenholzarten" ein wissenschaftlich nicht begruendetes Dogma. Centralbl. f. d. ges. Forstwesen, 30 (1904).

[7] Toumey, J. W. The Relation of Gray Birch to the Regeneration of White Pine, Journal of Forestry, Vol. XVII, No. 1.

[8] Zon, Raphael, and Graves, Henry S. Light in Relation to Tree Growth. U. S. D. A. Bul. 92.

to penetrate to the interior of the crown, while on the other hand, a tree like the black locust with compound leaves having small leaflets, permits an abundance of light to reach the interior of the crown. Although the latter species has a relatively large number of branch orders as compared to the umbrella tree, it is less tolerant.

OBJECT OF THE STUDY

For some years foresters have been attempting to use data on the maximum number of branch orders in the various species in developing empirical scales of tolerance. The data available have been fragmentary and for the most part based on the early work of Wiesner. By a comprehensive field study of twenty-two species in southern Connecticut, it was believed that definite conclusions could be drawn as to the practicability of using branch orders as an index of tolerance, particularly for southern New England.

METHOD OF STUDY

Before going out into the field to make the necessary observations, a quantity of sheets were drawn up upon which the data could be recorded numerically, thus facilitating the work. The maximum number of branch orders that could be found, was recorded for the lower, middle and upper crown of each tree noted. The diameter breast high, site quality, position of the tree in relation to the crown canopy, and wherever possible, the size of the ultimate twigs, were also recorded. Observations were made on as many different species and on the various qualities of site and positions in the crown canopy as was feasible. Trees having distinct orders of branching and open crowns as red maple, white ash and hickory, were observed without difficulty with the unaided eye. Those having dense crowns and small twigs were viewed through a high powered prism binocular.

In counting the maximum number of branch orders, any branch emanating from the main stem was considered a branch of the first order. From branch order number one a lateral branch was selected as a typical branch of the second order. Then on this second branch order was selected a branch of the third order. In this manner the orders of branching were followed out until no more were formed. By viewing each tree from all sides and making several counts, the highest number of branch orders was determined for the lower, the middle and the upper crown.

Whenever a branch forked, each extension of the branch above the fork was considered as the same order of branching as the part below the fork. With such species as elm, the oaks and the birches, where forking occurs a great deal, the utmost care had to be used that forked limbs were not included as branches of a higher order. The lateral branches of the birches and elms particularly, emanate from the parent branch at a small acute angle, which makes the orders of branching resemble forking. This further complicates the making of branch order counts on these species and increases the possibility of error. Therefore, in order not to class the branches above forks as being of higher orders, all branches of equal weight—that is, of equal diameter and of approximately the same length—just above a fork, were considered as being but extensions of the branch below the fork and of the same order. As a further elimination of a possible source of error in case of a doubtful fork or branch, a lateral branch was always selected below the point of doubt, the number of branch orders traced out on that, and the number checked with the former reading.

Many species which grow in the open or in poorly stocked stands are strongly deliquescent. They develop short boles from which extend upward from a common or adjacent fork, two or more large limbs which form the main crown of the tree. These large limbs were not considered as distinct branch orders but as part of the main stem.

Buds on short spurs, as occurring in the birches, were not counted as separate branch orders. The buds of all species were discounted similarly, no branch orders being recognized until they had actually formed.

RESULTS OF THE INVESTIGATION

Tables are presented herein which show: (*a*) the average maximum number of branch orders in each species studied without reference to the size of the tree, quality of the site, position in the crown, or density of the stand, (*b*) the effect of site quality upon the average maximum number of branch orders in the species, (*c*) the relation between the diameter breast height in stocked stands and the average maximum number of branch orders, (*d*) the effect of dominance upon the average maximum number of branch orders, (*e*) the effect of the diameter of the ultimate twigs and the area of leaf surface on the average maximum number of branch orders, (*f*) comparison between existing empirical table of tolerance of southern New England and the tables of tolerance as determined by branch orders.

Twenty-two species were studied and branch order counts varying from 30 to 120 were made for each species. The maximum number of branch orders was determined for three parts of the crown, namely for the upper, the middle and the lower.

Table 2 shows the average maximum number of branch orders for each of the species in the different portions of the crown, together with the average of all the readings. These averages include all of the observations made, and embrace trees from all sites, of all sizes and positions in the canopy. One-third of the total number of observations was made on the upper crown, one-third on the middle and one-third on the lower.

TABLE 2.—*Twenty-two Species Showing the Average Maximum Number of Branch Orders in Each.*

Species	Total number of observations	Average maximum number of branch orders			
		Upper crown	Middle crown	Lower crown	Average of all readings
Hemlock	60	5.00	5.55	6.20	5.58
Black oak	60	4.90	5.01	5.45	5.15
Beech	60	4.70	5.05	5.05	4.93
Scarlet oak	30	4.90	5.00	4.90	4.93
White elm	60	4.70	4.85	5.15	4.90
Sugar maple	60	4.40	4.85	5.25	4.83
Red maple	120	4.28	4.65	4.85	4.59
Red oak	120	4.20	4.65	4.88	4.58
Chestnut oak	60	4.10	4.50	4.70	4.43
Red cedar	30	4.20	4.50	4.60	4.43
White pine	60	3.75	4.50	4.70	4.32
Black birch	90	4.13	4.40	4.30	4.27
White oak	120	4.00	4.23	4.57	4.27
Yellow birch	60	4.10	4.20	4.40	4.23
Shagbark hickory	60	4.05	4.25	4.20	4.17
Basswood	30	4.00	4.10	4.30	4.13
Tulip poplar	90	3.70	4.17	4.17	4.12
Gray birch	60	4.00	4.15	4.20	4.12
Sycamore	60	3.90	4.10	4.25	4.08
Mockernut	60	3.95	4.00	4.05	4.00
Largetooth aspen	60	3.55	3.85	4.05	3.82
White ash	90	3.07	3.57	3.97	3.52

The highest average number of branch orders occurs at the lower portion of the crown in all of the species studied except scarlet oak, black birch, and shagbark hickory. This number decreases in the middle crown and is smallest at the top of the tree. The three species noted above as exceptions to this rule have the greatest average maxi-

mum number of orders in the middle crown. Most of the trees examined of these species occurred in thinly stocked stands. Hence the crowns were well formed with the largest limbs in the central part. It was on these large limbs that the highest maximum number of branch orders was found. From Table 2 it is evident that the highest number of branch orders usually occurs on the oldest branches of the tree, while the top, being the youngest, has the least number.

TABLE 3.—*Relation Between the Quality of Site and the Average Maximum Number of Branch Orders.*

Species	Site quality					
	Number of observations	I	Number of observations	II	Number of observations	III
Black oak	9	5.22	33	5.00	18	5.16
White elm	27	5.13	33	4.78	....	....
Sugar maple	....	....	36	4.82	24	4.78
Red maple	66	4.57	21	4.27	....	....
Red oak	....	....	69	4.59	51	4.74
Chestnut oak	....	....	24	4.46	36	4.42
Yellow birch	18	4.17	42	4.26	....	....
Shagbark hickory	33	4.36	15	3.60	12	4.33
Basswood	....	....	15	4.20	12	4.08
Tulip poplar	24	4.29	54	3.98	12	4.17
Gray birch	21	4.14	39	4.10	....	....
White ash	....	....	45	3.35	36	3.41
Sycamore	18	4.00	42	4.12	....	....
Black birch	....	....	15	4.40	75	4.27
Beech	....	....	48	5.04	12	4.50
White oak	24	5.00	9	4.44	57	3.93
Scarlet oak	21	4.76	9	5.33	....	....
Mockernut	6	4.67	42	4.05	12	3.50

From a study of Table 3 it is evident that on the better quality soils, the trees in general have a greater average maximum number of branch orders than do those of corresponding species on poorer sites. Due, however, to considerable variation in the diameter of the trees of various species, which exerts a marked influence upon the maximum number of branch orders and is indicated in Table 4, the average maximum number of branch orders of trees on poorer sites was sometimes found to be greater than on better soils. This is true of shagbark hickory, white ash, sycamore and scarlet oak. The other variations can not be accounted for as the average diameters on the different sites were approximately the same and all other factors were apparently equal.

TABLE 4.—*Relation Between the Diameter Breast High and the Average Maximum Number of Branch Orders.*

Species	Diameter breast high									
	Number of observations	4″–7″ inclusive	Number of observations	8″–11″ inclusive	Number of observations	12″–15″ inclusive	Number of observations	16″–19″ inclusive	Number of observations	20″–23″ inclusive
Red maple	9	4.69	63	4.49	36	4.64	....	....	....	....
Red oak	9	4.33	63	4.57	36	4.67	6	4.17	6	5.00
Chestnut oak	15	4.27	30	4.40	12	4.75	....	....	....	....
White pine	27	3.96	18	4.67	9	4.22	....	....	....	....
Tulip poplar	18	3.50	48	4.02	24	4.43	....	....	....	....
Sycamore	15	3.33	18	4.15	18	5.27	9	4.50	....	....
White ash	36	3.13	42	3.44	6	3.67	3	4.67	....	....
Black birch	39	4.28	24	4.25	....	....	....	....	....	....
Yellow birch	27	4.26	24	4.21	3	4.33	....	....	....	....
Largetooth aspen	36	3.67	18	3.78	....	....	3	5.00	....	....
Beech	30	4.87	12	4.75	3	5.00	....	....	....	....
White oak	54	3.93	12	4.50	6	4.50	....	....	....	....
Sugar maple	36	4.72	21	4.95	....	....	....	....	....	....
Hemlock	....	....	12	5.50	12	5.67	12	5.67	6	6.33
Black oak	15	4.87	36	5.25	6	5.17	9	5.17	....	....
White elm	....	....	12	4.75	12	4.92	6	4.33	....	....

Table 4 indicates that there is a general tendency for the maximum number of branch orders to be increased as the trees become larger. There are a number of exceptions, however. Several of these exceptions can be accounted for by the few observations which were made in some of the diameter classes. Thus, in the 4-7 inch diameter class of red maple, only three trees were observed, all of which were on Quality I soil. Each tree had a relatively high maximum number of branch orders. Consequently, the average maximum number of branch orders in this group is higher than for the larger trees. Likewise, only three trees were studied in the 12-15 inch diameter class of white pine. In the case of black birch, 50 per cent of the trees in the 8-11 inch diameter class were on Quality III soil, whereas all of the trees in the 4-7 inch diameter class occurred on Quality I soil. Apparently the better quality soil exerted a stronger influence upon the formation of branch orders than did the size of the trees. There seems to be no plausible reason for the other exceptions.

Trees which occur in the open receive plenty of light on all sides, so produce relatively larger crowns than do similar species occurring in stocked stands. Those in the open have short, thick boles and large heavy crowns, while those in stands have long boles with relatively smaller diameters and small compact crowns. Therefore, we know that the branches forming the lower crown of a tree in the open are older and usually larger than those of a tree of a similar species and equal age growing in a stocked stand, because the tree in the stand lost its lower branches by self pruning, whereas those of the tree in the open were developed and retained. Preceding tables have shown that in the majority of cases the larger, hence usually older tree or portion of tree has the highest average maximum number of branch orders. Therefore we would expect to find a higher average maximum number of branch orders on trees occurring in the open. A tulip poplar—an intolerant species—about 30 inches in diameter standing in the open was noted as having 6-7 branch orders in the lower crown, whereas 5 was the highest number noted in stands, and the average for 30 trees was only 4.12.

In a stocked stand the light intensity is diminished gradually from the crowns of the dominant trees to those which are suppressed. The dominant trees receive the most light and for that reason usually have large thrifty crowns and a higher maximum number of branch orders than trees receiving less light. The lower a tree stands in reference to the general level of the crown canopy the less vegetative develop-

TABLE 5.—*Relation Between Dominance and the Average Maximum Number of Branch Orders.*

Species	Open stands		Stocked stands							
	Number of observations		Number of observations	Dominant	Number of observations	Co-dominant	Number of observations	Intermediate	Number of observations	Suppressed
Hemlock	12	5.67	9	5.56	24	5.58	12	5.50	3	5.67
Black oak	....	....	27	5.22	24	5.11	6	4.50	....	....
Beech	6	5.83	3	5.00	15	4.93	21	4.76	15	4.87
Scarlet oak	9	5.33	6	5.00	12	4.75	3	4.33	....	....
White elm	30	5.10	9	4.67	21	4.76	....	....	....	....
Sugar maple	6	4.33	12	5.17	30	5.00	9	4.44	3	4.00
Red maple	9	5.11	12	4.75	90	4.53	3	4.33	3	4.33
Red oak	....	....	27	4.85	87	4.48	6	4.33	....	....
Chestnut oak	....	....	18	4.56	42	4.38	....	....	....	....
Red cedar	....	....	12	4.33	12	4.42	....	....	3	4.33
White pine	....	....	15	3.80	33	4.55	6	4.33	3	4.00
Black birch	15	4.60	21	4.38	45	4.22	3	4.67	9	3.78
White oak	15	5.40	12	4.42	42	3.97	15	3.93	6	4.00
Yellow birch	....	....	6	4.83	42	4.14	12	4.25	....	....
Shagbark hickory	21	4.53	3	4.33	27	4.00	6	3.50	3	4.33
Basswood	....	....	6	4.33	21	4.10	3	4.00	....	....
Tulip poplar	....	....	36	4.23	42	3.97	3	3.67	3	3.00
Gray birch	6	5.00	30	4.00	15	4.20	9	3.78	....	....
Sycamore	....	....	36	4.64	18	3.72	3	3.00	....	....
Mockernut	39	4.38	6	3.33	12	3.50	....	....	3	2.33
Largetooth aspen	....	....	15	4.13	42	3.74	....	....	....	....
White ash	3	5.00	33	3.24	51	3.43	3	3.33	....	....

ment is it capable of. Hence, it usually will have a small maximum number of branch orders.

While Table 5 indicates that there is a general tendency for an increase in the maximum number of branch orders with an increase in the amount of light which a tree receives, because of an insufficient number of observations for many of the species, a true relation between the various crown classes can not be shown. For 13 species, only one tree was recorded in some one of the dominance groupings, so that little dependence can be placed upon the results in these cases.

TABLE 6.—*Relation Between the Diameter of the Ultimate Twig, Area of Leaf Surface and the Average Maximum Number of Branch Orders.*

Species	Average diameter of ultimate twigs (inches)	Surface area of average leaf (square inches)	Average maximum number of branch orders
Hemlock	0.03	....	5.58
Black oak	.10	7.63	5.15
Beech	.04	5.08	4.93
Scarlet oak	.10	3.47	4.93
White elm	.04	5.23	4.90
Sugar maple	.08	8.99	4.83
Red maple	.07	8.79	4.59
Red oak	.10	7.75	4.58
Chestnut oak	.10	10.64	4.43
Red cedar	.02	....	4.43
White pine	.08	....	4.32
Black birch	.04	3.56	4.27
White oak	.08	7.27	4.27
Yellow birch	.03	4.19	4.23
Shagbark hickory	.18	31.17	4.17
Basswood	.08	11.94	4.13
Tulip poplar	.13	10.54	4.12
Gray birch	.03	3.00	4.12
Sycamore	.08	20.66	4.08
Mockernut hickory	.19	17.39	4.00
Largetooth aspen	.10	5.75	3.82
White ash	.15	20.76	3.52

In Table 6 the surface areas of the leaves were obtained from Sargent's Silva, wherein are natural size drawings of typical leaf parts of trees. In a few instances the areas were checked up by measuring the surface of leaves of herbarium specimens.

The diameters of the ultimate twigs were measured in the field, the average diameter recorded being the average of ten measurements.

A comparison of the diameter of the ultimate twigs with the area of the leaves borne by them shows that the two are in direct proportion.

Large ultimate twigs produce large leaves, while small leaves are produced by small twigged species.

The relation between ultimate twigs or leaf surface, and the maximum number of branch orders is not a very apparent one. Although in a good many instances the average maximum number of branch orders decreases with an increase in the size of the ultimate twig or of the leaf surface, it does not always prove true. For example, gray birch which has a smaller leaf surface and a finer twig than the other birches, elm, and beech, which would seem to throw it into the tolerant class, is very intolerant.

A study of Table 6 indicates that in general those species which have large ultimate twigs have few branch orders. Tulip poplar, ash and the hickories are examples of this. A glance at the column giving the average diameter of the ultimate twigs shows that the oaks seem to be placed too high in the column in comparison with their tolerance. This has been noted in every table, so the position of the oaks should be discounted accordingly.

It is evident that the tables based on the average maximum number of branch orders only very remotely correspond with the accepted empirical table for this region. All of the oaks occur much too high in the scale. Red cedar is also too near the tolerant end of the table. Basswood, on the other hand, appears in the intolerant group when, according to the empirical table, it should be in the tolerant. These are the most striking discrepancies, yet with the exception of hemlock and a few others, none of the species in the various columns actually match with the empirical table.

It was expected that the position of black oak would be too high in the tables, because the trees of that species were for the most part located in park-like areas within New Haven. These stands were heavily thinned years ago, and the crowns have enlarged greatly in closing the crown canopy again. Consequently, each tree noted had a high maximum number of branch orders. In the case of basswood, however, the trees being on poor soil and of small diameter had very poorly developed crowns. Hence, here it was expected that the average maximum number of branch orders would be a great deal too low. Beech occurs below sugar maple and elm in most of the tables. Upon referring to the field data, however, it is evident that the beech trees measured were relatively smaller than those of the two species mentioned above. Fifty per cent of the beech trees recorded were less than 6 inches in diameter. White pine also occurs too low which is to be expected since 70 per

TABLE 7.—*Comparison of the Tables of Tolerance as Determined by Branch Orders with the Empirical Table of Tolerance for Southern New England.*

Empirical table of tolerance for southern New England in order of tolerance (most tolerant first)	Species arranged according to the average maximum number of branch orders				
	Trees from all sites used of all diameters	Trees from all sites, diameter 8"–15" inclusive	Trees from site quality II, all sizes	Trees from site quality II, diameter 8"–15" inclusive	Lower crown readings only. All sites and all diameters
Hemlock	Hemlock	Hemlock	Hemlock	Hemlock	Hemlock
Beech	Black oak	Black oak	Scarlet oak	Black oak	Black oak
Sugar maple	Beech	Red cedar	Black oak	Scarlet oak	Sugar maple
White elm	Scarlet oak	Sugar maple	Red cedar	Red cedar	White elm
Basswood	White elm	Beech	Sugar maple	Sugar maple	Beech
Red maple	Sugar maple	White elm	White elm	White elm	Scarlet oak
White pine	Red maple	Scarlet oak	Red oak	Beech	Red oak
Black birch	Red oak	Red oak	Beech	Red oak	Red maple
Yellow birch	Chestnut oak	Chestnut oak	Chestnut oak	Chestnut oak	White pine
Red oak	Red cedar	Red maple	White oak	White oak	Chestnut oak
Black oak	White pine	White oak	Black birch	Red maple	Red cedar
Sycamore	Black birch	White pine	Red maple	Black birch	White oak
Scarlet oak	White oak	Yellow birch	Yellow birch	Yellow birch	Yellow birch
White oak	Yellow birch	Black birch	Basswood	Basswood	Basswood
Chestnut oak	Shagbark hickory	Tulip poplar	Sycamore	Sycamore	Black birch
Mockernut hickory	Basswood	Sycamore	Gray birch	White pine	Sycamore
Shagbark hickory	Tulip poplar	Basswood	Mockernut	Tulip poplar	Shagbark hickory
Tulip poplar	Gray birch	Shagbark hickory	Largetooth aspen	Gray birch	Gray birch
White ash	Sycamore	Gray birch	Tulip poplar	Largetooth aspen	Tulip poplar
Red cedar	Mockernut	Largetooth aspen	White pine	Shagbark hickory	Mockernut
Largetooth aspen	Largetooth aspen	White ash	Shagbark hickory	Mockernut	Largetooth aspen
Gray birch	White ash	Mockernut	White ash	White ash	White ash

cent of the trees recorded were scraggly individuals found on Class III sites. Practically all of the sycamores studied had extremely small tops. There was a marked decrease in the maximum number of branch orders in trees 6 inches and less in diameter. Hence, sycamore is likewise below the position in which it normally would be found. Of the yellow birch and black birch recorded, about 50 per cent of the former and 40 per cent of the latter were 6 inches or less in diameter. As a result these two species are too low in the scale. Red cedar is conspicuously out of place, and is the one species for which there seems to be no explanation.

The closest correspondence between the tables occurs in the case of the intolerant and very intolerant species. Although the species do not correspond across columns, the intolerant end of each table is composed of intolerant and very intolerant species exclusively.

BRANCH ORDERS AS AN INDEX OF TOLERANCE

The capacity of the tree to develop and reproduce in a stocked stand is reflected in the maximum number of branch orders that it can develop and retain. Due, however, to many factors which influence the life and development of the tree, this relation may often seem not to exist. Table 7 shows how greatly the position of the species change under the different groupings of site and diameter class. Hence, the necessity for uniform conditions in order to develop a reliable table of tolerance. In this study, due to several widely divergent factors, the maximum number of branch orders, although pointing out general relations between the tolerance of various species, fails to show anything like accurate differentiations between them.

Branch orders are not an accurate index of tolerance because of a number of factors which bring about variations in the maximum number which can occur. These factors exert a powerful influence upon the vigor and growth of trees, and act with different degrees of intensity upon different species. In brief, the maximum number of branch orders varies with:

(1) *Site quality.*—The number is higher on first class sites than on poorer ones, the poorest sites having the lowest number.

(2) *Age or diameter.*—The number is higher for older trees. This is not necessarily true for trees in the sapling stage, but is undoubtedly so in the case of trees past the pole stage (12 inches d.b.h.).

(3) *Position in the overwood.*—Trees in the open have a higher and more nearly uniform number of orders. Trees in stocked stands have

in general, fewer orders than those of like species in the open. There is a general tendency for the maximum number of branch orders to become less as the plain of the crown is lowered below the general level of the crown canopy.

(4) *Position of limbs in relation to the individual crown.*—The lower crown has a higher maximum number of branch orders than the middle crown, while the upper portion of the tree has the least number.

(5) *The diameter of the ultimate twig.*—The number of orders is usually less for species having large twigs, than for those which have small ones.

(6) *The leaf surface of individual leaves.*—Species having large leaves usually have fewer orders than those having small leaves.

(7) *History of the stand.*—Trees growing in stands which have been thinned, thus allowing the crowns to enlarge, have a higher maximum number of branch orders than do those of the same species which have not been relieved from crown competition. Insect and mechanical injury also influence the orders of branching so that the number may be abnormally high or low.

Perhaps one of the most important reasons why branch orders are not an accurate measure of tolerance is on account of the narrow range between the lower and upper limits of the maximum number of branch orders formed; namely, three and eight. When one takes into consideration the great variation between the tolerant, intermediate and intolerant tree species of any one region, it is obvious that the variations established by branch order studies will not be very determinate.

Therefore, because of the close proximity of the lower and upper limits of the number of branch orders formed, together with the difficulty of locating trees which have developed under similar conditions, it would seem that tables of tolerance as determined by branch orders are not of sufficient accuracy to warrant their preparation.

THE INTOLERANCE OF WESTERN YELLOW PINE REGARDED AS A REGULATING FACTOR IN THE MAINTENANCE OF THE TYPE

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In defining the silvical characteristics of forest trees we generally emphasize their relationship in regard to tolerance, or ability to endure shade. The degree of tolerance varies not only among the different species of trees, but also for a given species itself depending on the conditions under which it grows. Thus we often speak of a tree being more tolerant on moist than on dry soils, and such a relationship must therefore imply that tolerance is inter-related with soil moisture. A tree is said to be *intolerant* when it seems to require full sunlight in order to grow and thrive. Some species become intolerant only as they grow older and may even be quite tolerant of shade in the seedling and sapling stages. Considering western yellow pine, however, we have here a tree which appears to be intolerant of shade at all stages of its growth, although like most species its *relative* tolerance varies directly with the amount of soil moisture available. But in general, it requires full sunlight even in the seedling stage, for while seedlings do succeed in getting started in the shade they seldom survive beyond the first or second season.[1]

Obviously the observation of these facts is of fundamental value as a guide to the right silvicultural method to apply in the management of this type and as such may be considered sufficient. But, why is this species so intolerant and what purpose does this characteristic serve? The answer to such a question may seem to have little or no practical value. But let us see if it isn't of value. At any rate a little speculation about the matter will do no harm. In the absence of definite facts let us question the subject further as a means of arriving at the solution of the problem. First of all, doesn't the existence of the yellow pine forest, as a unit, depend, under natural conditions, upon the proper relationship being maintained between the mature stand and the reproduction? In other words, isn't it essential because of the limited supply of moisture available in this type that restocking should

[1] Pearson has given an exhaustive discussion of this matter in his report on "Reproduction of Western Yellow Pine."

be prevented until the older trees have matured? Obviously, this must be so, because assuming that the seedlings of this species *were* tolerant and therefore succeeded in becoming established under the crowns of the older trees during favorable periods, they would perish after a number of years owing to their competition with the older stand for moisture. In reality we do not have reproduction coming in until the stand has matured. Or to put the matter in teleological terms, the forest has no need of restocking until it has matured, and owing to the adverse conditions peculiar to this type restocking before maturity might be detrimental to both the older and younger generation.

In the course of evolution each species determines its own life cycle; the number of individuals of any species which can live on a given unit of area depends first of all upon the requirements of that species and secondly, upon the condition necessary to its existence. Moreover, the species growing on a given site will be found to be the one best adapted to it. If it is a tolerant one the indications are that ample moisture is available, the stand will generally be dense and reproduction will be seen to establish itself in the shade of the older trees. On the other hand, the presence of an intolerant species indicates a limited moisture supply, the stand is generally open, and reproduction does not become established until the older stand has matured.

Returning to our discussion regarding the intolerance of yellow pine we may rightly infer that this characteristic serves a distinct purpose; namely, as a factor which tends to maintain the proper proportion between the older and younger generation of trees in accordance with the sustaining capacity of the site. If this inference is correct the silvicultural value of it must be obvious. For, it shows us that we should not expect to secure reproduction until the stand is mature, but moreover that because regeneration is a phenomenon correlative with maturity of the forest we must not cut the old stand before reproduction has become established. This is in fact what we are just beginning to learn through the long and detailed process of analyzing the physical requirements of the species. The question therefore arises—wouldn't it be better sometimes to take a more philosophical attitude toward our silvical problems than to try to answer them by the accumulation of facts alone? Through inference we often come nearer to the truth regarding the how and why of a complex biological phenomenon than we do through a mere analysis of the factors constituting it.

BETTER FORESTRY THROUGH BETTER UTILIZATION[1]

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In its most limited sense, forestry has been defined as the management of growing timber; in its broadest sense as the science, art, and business of producing, reproducing, and improving forests for forest purposes and of practicing the most appropriate methods of harvesting, converting, and disposing profitably of forest produce.

How near forest utilization is a part of forestry has been a much mooted question. It is becoming more and more recognized, however, that utilization plays an important part in the practice of forestry, but just where utilization of wood, in its course from the forest to the fabricated wooden article, ceases to bear a direct relation is still another question. The object of this paper is to point out that regardless of where waste of raw material may occur, such waste, its elimination or its utilization, will still have a most vital effect on the business of forestry.

In this country the product of the forest is subjected to greater losses than any other raw material. These losses first in the woods, then at the sawmill, and finally in the wood-working factory aggregate more than 80 per cent of the volume of the original forest. It is true that many losses are unavoidable, but it is equally true that many are needless wastes. Elimination of all loss in harvesting and using forest products is the ideal, but nevertheless one that can not be attained under present conditions. Further research on wood utilization will contribute much in that direction, but meanwhile the waste problem must be attacked from another angle also.

This is by more complete utilization of material now disposed of as waste and includes both unavoidable as well as avoidable waste. Ways and means of making use of waste in the past have been largely through utilization of chemical means and accomplishments in this line have been remarkable. Results of recent research at the Forest Prod-

[1] Read before the annual meeting of the Society of American Foresters, Dec. 27, 1921, Toronto, Canada.

ucts Laboratory of the U. S. Forest Service show that in merely using sodium carbonate in the process of destructive distillation production of wood alcohol can be increased from 50 to 100 per cent; that ethyl alcohol can be produced from the pulp held in solution by spent liquor in the sulphiate process of pulping wood, thus utilizing a large portion of the 55 per cent of original wood heretofore wasted; that used news-print can be profitably deinked and remanufactured into paper; that all wood subjected to decay can be economically preserved by chemical treatment; and that many other savings in raw material can be made through chemical methods of treatment and use. Moreover, research is pointing out ways for eliminating wood losses through physical means. Through exhaustive tests on the mechanical properties of wood allowable working stresses for heavy timbers can be increased by 20 per cent effecting an annual saving of two or more billion feet of timber. Better kiln drying methods will permit complete utilization of another two billion feet now lost each year through inefficient but entirely avoidable drying methods. And better methods of box and crate construction will conserve over one billion feet of lumber as well as millions of dollars worth of commodities lost annually in shipment.

Granted, however, that these reductions and elimination of losses are resulting from present day research, there is still an enormous field almost untouched but which, from early indications, promises to present still greater opportunities for conservation of raw material. Those in the industries who are acquainted with the facts state that the new work on wood waste problems just undertaken by the Forest Products Laboratory is the greatest economic movement ever initiated in connection with the manufacture and use of forest products. Moreover, its scope is enormous, the field unlimited. The underlying principle of this new work is standardization of products and requirements of all wood-using and consuming industries, and more effective wood utilization through mechanical means as distinguished from chemical and physical means.

In this new research two investigations stand out most prominently although they hardly touch the field.

The first of these is the standardization of nomenclature, sizes, grades, and specifications for lumber, cross ties, and other wooden products.

Lumber is today manufactured from more than thirty commercial species in general use and each species is graded, inspected, and marketed under its own set of rules. These rules are in most instances

the outgrowth of early conditions when the use of lumber was not refined as it is today. The result is that present lumber grades not only do not fully meet the requirements of use but they are so complex and misleading that the average consumer has no assurance that he is getting the material best suited for his needs. Similarly, cross ties are now manufactured, marketed, and utilized under varying conditions as to size, grade, species, inspection, price in relation to quality of material, etc. In the tie industry as well, either the manufacturer or consumer suffers, as a rule, from lack of standardization.

The objects and advantages of standardization of both lumber and ties are manifold. The most important are to simplify purchases by making possible a common language for all; increase efficiency, ease and accuracy of inspection; render possible the substitution of one species for another with the assurance of getting the species desired and of the same size and grade; render statistical interpretation more intelligible in comparing prices of competitive species, sizes, and grades; reduce selling costs, and unit costs to the public; stabilize production and employment; and eliminate indecision both in production and utilization—one of the most prolific causes of inefficiency and waste.

This second important research problem in the new program will produce earlier and more far reaching results in bringing about more complete utilization of wood. This project deals with standardization of the small dimension stock requirements of all secondary wood-using industries. It involves the production and marketing of this material by the sawmill and its use by the consumer in the form of ready-cut rough stock in the required small sizes.

The secondary wood-using industries now consume annually over eight billion board feet of lumber. In present practice these industries purchase and use high grade lumber and planking, the products of the sawmill, and after shipment to the wood-using factory, remanufacture it into stock of small sizes at great losses in raw material, transportation charges, and operating expense. The waste in raw material alone incident to this form of converting wood, considering all grades, averages 50 per cent; while if the waste incident to the conversion of the log into the original lumber and planking is considered in the final utilization, then only about 17 to 20 per cent of the total volume of the tree is obtained.

On the other hand, it is unnecessary to use high grade boards and plank for the production of the requirements of these industries. Al-

though this stock must in itself be clear and of high quality, it can, on account of the small sizes and shapes usually required, be produced from low grade raw material, lumber by-products, and much other material now disposed of as waste at the sawmill and in logging operations. Slabs, edgings, and long trimmings, will yield this material and also much can be made from the lowest grades of lumber now produced in comparatively high and increasing proportions in every mill operation and so often yarded only to rot or be given away for the cost of handling.

With dimension stock standards and markets, and by education of the producer and consumer, the sawmill can convert these by-products and low grade material directly into the form and quality of material required by the wood-using industries. This will lessen the industries' demand for high grade lumber and will afford a profitable outlet for material now unutilized. In turn the annual drain on our remaining timber supply will be relieved to the extent of four or five billion board feet.

Detailed investigations by the Forest Products Laboratory in connection with this method of utilization of wood waste have been under way for several months. Time, cost, and efficiency studies are being conducted in chair and wood-turning factories. Likewise, other industries such as the furniture, automobile, vehicle, etc., will be covered. Studies of similar scope will be conducted in logging and milling operations.

Now how will conditions existing in logging, milling, and manufacturing operations be effected by this new method of converting the standing tree into the products required by wood-using industries, and by standardization of the products and demands of the producer and consumer?

Sawmills are today usually located near the source of raw material, usually in the smaller communities. There 25 per cent of the original volume of the forest is left in the woods. About 45 per cent is wasted at the mill. Here the logs are manufactured into boards, plank, and structural timbers of random sizes, usually regardless of whether they meet the requirements of use. Operating expenses are comparatively low because operations are carried on on land of low potential value, where living costs are low and where labor is economically employed.

Large quantities of boards and planking are then shipped to consuming factories where the material is rehandled, usually seasoned both in the open and in kilns, and finally resawn into small rough stock of

the various sizes required in the manufacture of innumerable wooden commodities. Seldom, if ever, is thought given to the widths or lengths of lumber most suitable for re-working into these articles. Defects and blemishes are scattered promiscuously throughout the pieces and in remanufacture the consumer must take chances on dodging them.

These manufacturing operations are carried on usually in the larger cities where overhead costs are extremely high, factory sites are costly, and labor is not as economically procured as in the woods or sawmills. Then also these consumers pay needless freight charges on this material they are compelled to waste. It is true that some of this material can be disposed of locally for fuel but only at a figure insignificant as compared with the original value.

In contrast, with these new methods of conversion practiced at the source of raw material, production costs for fabricated wooden articles will be lowered. Much of the 25 per cent of the forest now wasted in the woods and the 45 per cent wasted at the mill will be utilized for clear high grade marketable small dimension stock. The balance of unutilized waste and the 15 per cent or so of the volume of the forest now wasted at consuming plants throughout the United States will be concentrated at or near the mill and source of raw material. With this condition obtaining, chemical utilization of waste can be more universally practiced.

Finally what will be the effect upon economic conditions and the practice of forestry? A part of the manufacturing operations now conducted in the cities will be moved to the small forest communities and this will make for permanent forest employment. Much of the urban population will be transferred with these operations and this will stabilize forest communities. The more complete utilization of the products of the forest will greatly increase stumpage values.

And permanent forest employment, stabilized forest communities, and increased forest land and stumpage values are the heart and essence of real forestry.

SOME RELATIONS BETWEEN QUALITY OF SITE AND QUALITY OF MATURE TIMBER—WESTERN YELLOW PINE

By S. B. Show

Forest Examiner, U. S. Forest Service

The general relation between quality of site and quality of timber is perfectly obvious and well-known, and though both have been determined in many cases, there has apparently been no attempt to correlate them, and to determine the specific relation, if any exists.

Quality of timber in yellow and sugar pine, as understood in practice, is judged by the per cent of the total cut which goes into upper grades. In California, using the lumber grading rules of the California Sugar and White Pine Agency, the upper grades are No. 2 Shop and better, that is, 1 and 2 Clear, 3 Clear, Select, Australian, 1 Shop and 2 Shop. The quality of timber is described by saying that it cuts 30 per cent uppers, or whatever the amount may be.

In appraising National Forest timber, one of the most important steps is the determination of average selling price of the product, which is calculated on the estimated percentage of each grade and the selling price for each. The methods for determining the quality of standing timber have been worked out by Swift Berry (see his various papers). The field work consists of a tally by log grades of all logs in trees on sample areas. The office work consists of a laborious computation of the total footage of each grade in each diameter, species and log grade class. If the relative proportion of the several upper grades for timber of different qualities could be ascertained, a great deal of office work could be eliminated.

The Forest Service had up to January, 1919, accurate records of the quality of yellow pine timber for twenty-six different logging operations and stumpage appraisals. The per cent of uppers ranges from 15 to 69 per cent, most of the values falling between 20 and 40 per cent.

An analysis of these data has been made as described below.

METHOD OF COMPUTATION

Each operation and appraisal (the latter made by competent men, and checked against actual cut) is treated as a unit, disregarding the

amount of lumber cut. This varied, for different operations, from about 1 to 80 million board feet.

First, the data were grouped and averaged by arbitrary groups. Thus all from 10 to 20 per cent of upper grades, 21 to 30 per cent, etc., were thrown together.

Table 1 shows the results of this first step, averages only being given.

TABLE 1.—*Average Per Cent of Lumber Grades by Quality Classes.*

Lumber grade	Per cent of upper grades					
	10–20	21–30	31–40	41–50	51–60	61–70
1 and 2 Clear........	1.1	4.3	8.3	10.3	10.8	15.0
3 Clear..............	1.1	1.8	3.9	6.0	7.4	9.8
C Select.............	0.1	0.5	0.8	.7	1.6	0.5
Australian	0.1	0.7	1.7	1.6	....	1.3
1 Shop...............	4.5	7.0	8.9	13.3	16.8	22.5
2 Shop...............	10.3	10.7	14.0	15.5	16.6	19.4
Total..............	17.2	25.0	37.6	47.4	53.2	68.5

TABLE 2.—*Average Per Cent of Total Upper Grades Formed by Individual Lumber Grades.*

Lumber grade	Per cent					
	10–20	21–30	31–40	41–50	51–60	61–70
1 and 2 Clear........	6.4	17.2	22.1	21.7	20.3	21.9
3 Clear..............	6.4	7.2	10.4	12.6	13.9	14.3
C Select.............	0.6	2.0	2.1	1.5	3.0	0.7
Australian	0.6	2.8	4.5	3.4	....	1.8
1 Shop...............	26.2	28.0	23.7	28.1	31.5	32.8
2 Shop...............	59.8	42.8	37.2	32.7	31.3	28.5
Total..............	100.00	100.00	100.00	100.00	100.00	100.00
Clears...............	12.8	24.4	32.5	34.4	34.2	36.2
Shops	86.0	70.8	60.9	60.8	62.8	61.3

RESULTS

The next step is to take, for each quality class, the total upper grades as 100 per cent, and compute the per cent for each lumber grade on this basis. Thus in the 21 to 30 per cent class, averaging 25 per cent of uppers, the 1 and 2 Clear forms 17.2 per cent of the upper grades, 3 Clear 7.2 per cent, etc. Table 2 shows the results of this process.

First, it is very instructive to compare the relative proportions of Clears and of Shops. With low per cent of uppers, practically all of the upper grade lumber is Shop, while as per cent of upper grades increases, the proportion of Clears increases, and of Shops decreases. From about 40 per cent (of uppers) on, the proportion of Shops is constant at about 60 per cent, while Clears rise very slowly, taking up the decrease in Select and Australian.

Second, number 2 Shop closely parallels the average percentage for all Shops, and 1 Shop tends toward a uniform very gradual rise. The number 1 Shop exceeds number 2 just at about 60 per cent of uppers. It is found, too, that up to 17.5 per cent of uppers the 1 and 2 Clear and 3 Clear have the same proportions, while from 17.5 to 30 per cent the 1 and 2 Clears rise rapidly, then flatten out and from 40 per cent of uppers on, correspond closely to the percentages for all Clears. Number 3 Clear rises slowly and evenly, lying well below 1 and 2 Clear.

Number 2 Shop is distinct, as it falls with increase in per cent of uppers, while number 1 Shop and the Clears have the same general form, rising as the quality of timber improves.

The Select and Australian form a small and fairly constant per cent of the total uppers.

SITE QUALITY

Table 3 shows the relation between site quality, as indicated by average height of dominant mature trees, and quality of timber as expressed by per cent of upper grades. For a number of the timber sale operations upon which Table 1 is based, the average height of the timber is known, so that these points, which fell well distributed in total height of the stand, and especially between heights of 100 and 160 feet are well established.

The next step is to decide on a site classification plan. The one outlined here, admittedly a preliminary classification, is based on a yield study of western yellow pine made on the Lassen National Forest in 1919.

The criterion of site used is average height of dominant mature timber, the final selection of intervals and values in the rating system having been decided on after considerable field study.

Field determination of site can usually be most readily made by measuring heights of mature timber, and of course the results of this particular study apply only to the virgin forest.

TABLE 3.

Site	Height dominant mature trees	Height 100-year trees	Percentages of upper grades
I	150+	110	45+
II	131–150	95	32–45
III	111–130	84	20–32
IV	91–110	72	12–20
V	71–90	60	12 or less

This scheme is based on the well-recognized principle that height is a reliable index of site quality.

There is no pretense in this study, that the division into Site Quality classes as related to Quality of Timber is the final one. The present indicated relations should be regarded as tentative, subject to correction with further study.

Evidently the basic feature for field application is the material in Table 3. From this, assuming the accuracy of the data, the per cent of upper grades for any stand can easily be determined.

Obviously, per cent of uppers obtained depends not only on site quality but on relative proportion of age and size classes, the diameter limit to which timber is cut, and on density. In other words, we are dealing with the irregular virgin forest, and with partially standardized intensity of utilization. It may seem, therefore, that with so many variables it is futile to attempt correlation of site and timber qualities. The best answer to this is a frank admission that the relationships indicated are subject to variation in individual cases, but that in the writer's opinion, the standardization attained, the elimination of individual judgment in deciding on log grades, the great reduction in office work, may perhaps count in favor of the method.

TEST OF METHOD

In order to check results obtained by this method, and those obtained by actual tally of lumber cut, and by detailed stumpage appraisals, several sets of parallel computations were made. The per cent of each lumber grade averaged for all operations in the given quality class was determined. The per cents for certain individual operations, selected for wide divergence of per cent of the several grades from the per cents secured by averages, were also worked up.

Using these values, the average selling price of upper grades was

figured, using the average grade prices obtaining in California in 1918.

The value of individual grades in all the five examples varied widely from the corresponding values as computed from averages. The *total* percentages and selling prices of uppers, however, are in every case remarkably close, usually within 2 per cent by both methods of computing. In two of the examples with variations of $0.42 and $0.19, the differences are almost eliminated if compensation is made for the fact that per cent of uppers is slightly higher than average values used. If, instead of using the arithmetic averages of Table 1, smoothed off values are taken from a curve, the two methods of arriving at average selling prices are within about 1½ per cent of each other.

Within the past year the method has been tested in two cases by Logging Engineer J. H. Price and Forest Assistant Burnett Sanford of the Forest Service. The determination of grades by the usual log grading methods was also made. Only one of these tests need be given in detail.

Number of heights measured	19
Average height of timber	129 feet
Per cent uppers from curve	30 per cent
Per cent uppers usual calculation	30.5 per cent
Selling price, usual method	$10.94
Selling price, curve method	$10.92

The average selling prices, including low grades, were $28.86 to $28.98 for the two methods.

In the other test the per cent of uppers by the usual method was 40 per cent and by the curve method 41 per cent, with total selling prices for all grades of $29.80 and $30.62.

POSSIBLE APPLICATION

It seems not improbable that with further refinements of the proposed method, average per cent of uppers and average selling price of lumber can be obtained as follows:

Step 1.—Determine site quality on basis of total height of dominant mature trees.

Step 2.—From Table 3, get per cent of uppers indicated by height of timber.

Step 3.—From Table 2, get per cent of each grade indicated as result of Step 2.

Step 4.—Convert figures from Step 3 into per cent of total cut by grades.

Step 5.—Figure average selling price in usual way.

The method would work out as follows:

Step 1.—Average height 160.

Step 2.—Per cent of uppers 50.

		Per cent.
Step 3.—	1 and 2 Clear	22
	3 Clear	12
	Select and Australian	4
	1 Shop	28
	2 Shop	34
	Total	100
Step 4.—	1 and 2 Clear	11
	3 Clear	6
	Select and Australian	2
	1 Shop	14
	2 Shop	17
	Total	50

Step 5.—Usual computation.

RECOMMENDATIONS

Unless this whole plan of attack is totally incorrect in principle, it is simply a question of time until the data are refined enough to make its use advisable. The method should be checked against actual appraisals as much as possible. If it does work it will save a great amount of time and energy, and it offers enough promise of success to deserve a careful and impartial test.

THE MÄULE REACTION AS A MEANS OF DISTINGUISHING BETWEEN THE WOOD OF ANGIOSPERMS AND GYMNOSPERMS

By P. D. Sharma

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In a recent paper dealing with the significance of the lignin color reactions, Crocker[1] discusses the possibility of distinguishing the hardwoods from coniferous woods by means of a simple chemical test. In that paper, the results of the test on a limited number of hardwoods and coniferous woods are given and the suggestion is made that the Mäule reaction may be of considerable value in differentiating the woods of the Gymnosperms and the Angiosperms.

Since the Mäule reaction may not be generally known to foresters and because it was thought desirable to test it with a large number of different woods, the present work was undertaken. In brief, the Mäule reaction consists of treating the wood in succession with potassium permanganate solution, dilute hydrochloric acid and finally ammonia.

In the present work the following hardwoods and coniferous woods were tested with reference to their reaction to the Mäule test:

GYMNOSPERMS

FAMILY PINACEÆ

Pinus strobus, eastern white pine.
Pinus monticola, western white pine.
Pinus lambertiana, sugar pine.
Pinus resinosa, red pine.
Pinus ponderosa, western yellow pine.
Pinus taeda, loblolly pine.
Pinus echinata, shortleaf pine.
Pinus palustris, longleaf pine.
Abies balsamea, balsam fir.
Abies concolor, white fir.
Abies nobilis, noble fir.
Abies magnifica, red fir.
Juniperus virginiana, red juniper.
Larix laricina, tamarack.
Larix occidentalis, western larch.
Picea rubens, red spruce.
Picea engelmanni, Engelmann spruce.
Tsuga canadensis, hemlock.
Tsuga heterophylla, western hemlock.
Pseudotsuga taxifolia, Douglas fir.
Taxodium distichum, bald cypress.
Sequoia sempervirens, redwood.
Thuja plicata, western red cedar.
Chamæcyparis thyoides, white cedar.
Chamæcyparis lawsoniana, Port Orford cedar.

[1] Crocker, E. C. An experimental study of the significance of "lingnin" color reactions. Jour. Indust. Eng. Chem., 13: 625-627, 1921.

GYMNOSPERMS—continued

FAMILY TAXACEÆ

Tumion californicum, California torreya.

Taxus brevifolia, Pacific yew.

ANGIOSPERMS

Monocotyledons

FAMILY GRAMINEÆ

Dendrocalamus strictus, bamboo (Indian).

Dicotyledons

FAMILY JUGLANDACEÆ

Juglans cinerea, butternut.
Juglans nigra, black walnut
Hicoria pecan, pecan (hickory).
Hicoria ovata, shagbark hickory.

FAMILY SALICACEÆ

Populus deltoides, cottonwood.
Populus alba, white poplar.

FAMILY BETULACEÆ

Betula lutea, yellow birch.
Betula lenta, sweet birch.
Alnus oregona, red alder.
Carpinus caroliniana, blue beech.

FAMILY FAGACEÆ

Fagus astropunicea, beech.
Castanea dentata, chestnut.
Quercus alba, white oak.
Quercus rubra, red oak.

FAMILY ULMACEÆ

Ulmus americana, white elm.
Celtis occidentalis, hackberry.

FAMILY MORACEÆ

Morus rubra, red mulberry.
Toxylon pomiferum, osage orange.

FAMILY SANTALACEÆ

Santalum album, sandal wood (Indian).

FAMILY MAGNOLIACEÆ

Liriodendron tulipefera, tulip tree.

FAMILY LURACEÆ

Sassafras sassafras, sassafras.

FAMILY HAMAMELIDACEÆ

Liquidambar styraciflua, red gum.

FAMILY PLATANACEÆ

Platanus occidentalis, sycamore.

FAMILY ROSACEÆ

Cercocarpus ledifolius, mountain mahogany.
Prunus serotina, black cherry.
Pyrus americana, mountain ash.

FAMILY LEGUMINOSÆ

Gleditsia triaconthos, honey locust.
Gymnocladus dioicus, coffee tree.
Robinia pseudacacia, black locust.
Dalbergia sisso, sissoo or Shisham (Indian).

FAMILY ACERACEÆ

Acer macrophyllum, Oregon maple.
Acer negundo, box elder.
Acer saccharum, sugar maple.

FAMILY HIPPOCASTANACEÆ

Aesculus glabra, Ohio buckeye.

FAMILY TILIACEÆ

Tilia americana, basswood.

FAMILY CORNACEÆ

Nyssa sylvatica, black gum.

FAMILY EBENACEÆ

Diospyros virginiana, persimmon.

FAMILY OLEACEÆ

Fraxinus americana, white ash.

FAMILY VERBENACEÆ

Tectona grandis, teak (Indian).

FAMILY BIGNONIACEÆ

Catalpa catalpa, catalpa.

DISCUSSION

In every instance, a distinct red coloration resulted when the Mäule reaction was applied to wood of the Angiosperms (including a representative of the Monocotyledons, namely bamboo). When applied to the wood of the Gymnosperms, indefinite yellowish or brownish colors resulted. In order to obtain the best results, the permanganate solution should be allowed to soak well into the sample before applying the hydrochloric acid.

The various surfaces, that is, cross, radial and tangential, respond equally well to the reaction as does also heartwood or sapwood. In a few cases, where partially decayed wood was available, the results indicate that the reddish colors are obtained in the case of partially decayed wood of the Angiosperms and yellowish or brownish colors in the case of partially decayed of the Gymnosperms. When the natural color of the wood is pink (Gymnocladus dioicus) or brownish (Tectonia grandis) the color resulting from the reaction is not so distinct as in the case of the light colored woods. The pink or reddish color is not permanent but gradually fades out after a short period of time

The writer wishes to express his thanks to Dr. Henry Schmitz, in charge of the Laboratory of Forest Products School of Forestry, University of Idaho, for suggesting the problem and for directions as to methods of procedure.

POISONOUS WOODS

By George A. Garratt

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While making a study of cocobolo, the author became interested in the poisonous characteristics exhibited by certain tropical woods, and the following paragraphs are the result of an attempt to compile information in regard to the toxic properties of these woods. No attempt is made to give a detailed and exhaustive discussion of the poisonous effects in any case, the purpose of the article being simply to furnish some interesting and, in many cases, little known facts on the subject. A discussion of the botanical sources of the woods is included in those instances in which those sources are known.

Most of the woods of a poisonous nature are known to contain active principles, such as alkaloides, glucosides, essential oils or resins, which have been found to have a toxic effect on the human body, although in a few cases the active substances are as yet undetermined. It is quite probable that in the case of the essential oils or resins the toxic activity is due to glucosides contained in them rather than to the oils or resins themselves. The poisons contained in the wood may result in intense itching and swelling of the skin, inflammation of the membrane of the eye and nose, paralyzation of the motor nerves, heart depression, constitutional symptoms or other effects and in some instances serious illness has resulted. However, no case is known which resulted fatally.

No harmful effects are felt in handling the finished products made from any of these woods. It is only in the stages of wood working in which considerable dust arises that the toxic principles are liberated and the poisoning occurs.

COCOBOLO

One of the most valuable woods used in the United States in manufacturing knife handles and small turned articles comes from Central America under the trade name of cocobolo. This wood was first introduced into this country about 1878 and used in the cutlery trade. It made its appearance on the London market about the same time, under the name "red fox-wood."

Despite the length of time during which cocobolo has been in use, but little was known concerning its botanical source until very recently when the tree producing the wood was referred to the genus *Dalbergia.* At first a single species, *Dalbergia retusa,* was thought to be the only source of the wood, but late investigations have revealed the fact that this species is confined to Panama and that two others, *D. hypoleuca* of Costa Rica and Nicaragua and *D. granadillo* of Mexico, also produce cocobolo wood.

Like many other woods of the legume, or pea, family, cocobolo possesses to a very high degree the valuable characteristics of density, color and durability. Strong, hard, compact and fairly heavy, easily worked and of extreme durability, it is naturally in high favor with the cutlery and turnery trade. In color the wood varies from a light reddish-orange to a deep, rich red, or rose, beautifully marked with numerous, irregular, concentric markings of black or deep purple. An oily substance present in the wood not only makes it susceptible of a high degree of finish, but also tends to waterproof it and make it resistant to the influence of moisture, even when left in contact with water indefinitely. It is this latter characteristic that is mainly responsible for the supreme position that cocobolo holds in the cutlery trade.

The greatest demand for cocobolo comes from manufacturers of knife handles, brush backs, and small tool handles, but the wood is used also in the manufacture of chessmen, musical and scientific instruments, butts of billiard cues, and other articles which can utilize such a hard, heavy, strong, durable and beautiful wood. It is said that in the construction of first transisthmian railroad in Panama cocobolo was used to some extent for railroad ties.

It is unfortunate that a wood so valuable and so much in demand as cocobolo should exhibit poisonous characteristics to a marked degree. The nature of the toxic principles contained in the wood is as yet undetermined, but its action is similar to that of chloroxylonine, contained in satinwood, and it is thought to be an alkaloid of similar nature. Added weight is given to this belief by the discovery of small amounts of alkaloids in several other species of *Dalbergia.* However, one prominent authority, who made a study of the toxic principle contained in cocobolo, claims it to be an etherial oil. Experiments made at the Yale Medical School were unproductive in determining the source of the poison, but led to the belief that it was an oil.

Similar in its action to poison ivy, which contains a glucoside, this toxic principle results in an acute dermatitis, causing the skin to become inflamed and puffy and watery. The trouble first makes its appearance on the parts of the body with which the sawdust comes in contact, such as the hands, forearms, face and neck, but it may spread to other parts. Much annoyance and intense irritation result, but the poison is not dangerous, although its effects may occasionally be rather serious. The trouble is more pronounced during warm weather or at other times when the workmen perspire freely.

The users of cocobolo hold various opinions as to the relative poisonous properties of the wood from different regions. Some claim that the wood from Panama only is poisonous, others that only that from Nicaragua and Costa Rica, and still others state that that from all sources is equally troublesome.

As is the case with poison ivy, some people are entirely immune to the poison, others slightly susceptible and still others very susceptible. This last class of persons should never be permitted to work with cocobolo wood in the shop. Claim has been made that negroes are entirely immune, but this is not borne out in the experience of one company that employed negroes for the express purpose of working up cocobolo.

The solution to the problem of cocobolo poisoning lies in building up a working force of persons immune to the toxic action of the sawdust of this wood.

BOXWOOD

A number of entirely different woods go to make up that group commercially known as boxwoods. *Buxus,* the true boxwood genus, contributes but two species of commercial value. Perhaps the best known of these is the Turkish, or European box, *Buxus sempervirens,* which has a very wide range in the Eastern Hemisphere, extending over a large part of Europe and across Asia to Japan. Mostly a shrub in the northern part of its range, it is found in tree form in countries bordering the Mediterranean and Black Seas and the Himalayan Mountains and in England. The other species, *Buxus macowani,* the African or East London box, is confined to southwest Africa, where it is found in considerable quantity.

The other woods of this group bear no botanical relation to the true boxwoods, belonging to altogether different families. Chief among

them are the Knysna or Kamassi wood, *Gonioma kamassi* of South Africa, an inferior, poisonous box which will be discussed in following paragraphs, Maracaibo boxwood, *Aspidosperma vargassi,* the original Venezuelan wood which has been superceded by *Casearia praecox* and Baitoa, or San Domingan boxwood, *Phyllostylon brasiliensis,* from San Domingo, Eastern Cuba, Brazil and Argentina. This last named species belongs to the same family as our native elms and hackberries, but is not nearly so good a wood as the *Casearia praecox,* which is still the important one on the market. Two woods found in the United States which are sometimes called boxwoods are the flowering dogwood, or American or New England box, *Cornus florida,* and the Florida boxwood, *Schaefferia frutescens.*

Boxwood is a term applied without regard to botanical classification to a group of woods having certain physical properties. Practically all the woods of this group are light yellow in color, very hard and heavy, of fine texture and grain, very resistant to splitting and yield a fine surface when turned or planed. The best woods are used mainly for engraving, the inferior ones for rulers, mathematical instruments, tool handles, shuttles, inlaying, etc.

One of the woods for which there is very little market in the United States at present, but which is much in demand abroad is *Gonioma kamassi,* the Knysna boxwood or Kamassi wood from the extreme southeastern part of Africa. This is an inferior wood unsuited for engraving but used abroad in the manufacturing of rulers and shuttles. It contains an alkaloid of a toxic nature that is frequently poisonous to men employed in those stages of working the wood in which fine dust is created, such as in sawing and sandpapering. Men working in the dust for the first time are frequently subject to pain and inflammation of the eyelids and nose, dilation of the pupils of the eyes, symptoms resembling severe influenza and bronchial catarrh and dizziness. Later, if they persist in the work, they often become pale and jaundiced and suffer from asthma and cold sweats. The alkaloid is a heart depressant and a paralyzer of the motor nerves, similar in its action to the arrow poison, curare.

An English medical journal contains a reference to the occurrence of symptoms such as inflammation of the eyes, dilation of the pupils, dryness of the throat and catarrhal conditions lasting two or three days in men making rulers from Maracaibo boxwood, but the author has been unable to find any further account of such toxic characteristics of

this particular wood. It may be that this wood was erroneously termed Maracaibo boxwood and that it was in reality the Knysna box.

Poisoning by African boxwood is one of the industrial diseases recommended for compensation by the Industrial Compensation Act in England.

SATINWOOD

The satinwoods of commerce are derived from a number of different sources, but the West Indian wood, *Zanthoxylon flava*, and the East Indian variety, *Chloroxylon swietenia*, are the most important. Other species which are classed as satinwoods are Andaman satinwood, *Murrya exotica*, Brazil satinwood, *Esenbeckia sp.*, North American satinwood, *Zanthoxylon floridum*, pau setim or pau amarello, *Euloxophora paraensis*, satiné or bois de feroles, *Brosimum sp.*, and harewood or concha satinwood, source unknown. Most of these woods belong to the family Rutaceae which contains the American wafer ash and prickly ash.

The satinwoods are among the most beautiful of the lighter-colored precious woods, being very hard and heavy and with a deep yellow color, which when highly polished gives the effect of great limpid depths. The woods are used in the United States both in the solid and as veneer, going into the manufacture of furniture, pianos, coffins, flooring, brush and mirror-backs, musical instruments, inlaid work and parquetry.

The East Indian satinwood is obtained only from Ceylon, although the timber is indigenous to India where it is inferior in size and quality. There is considerable similarity between this wood and the West Indian satinwood from Porto Rico, San Domingo, Jamaica and the Florida Keys, but the latter is by far the better wood.

It is the East Indian wood, *Chloroxylon swietenia*, that possesses poisonous properties, although for a time it was thought that that from the West Indies also exhibited toxic characteristics. Investigation has served to show, however, that the poisoning results from a crystalline alkaloid, chloroxylonine, a powerful irritant present only in the former wood. Two resins and a fixed oil were also found to be present in this wood, all three of which are non-irritant to the skin of normal persons, but which act as irritants to those persons who have already experienced a chloroxylonine dermatitis. As is the case in practically all woods exhibiting poisonous qualities, the irritant is active only when the wood is in the form of sawdust or a fine powder.

Chloroxylonine results in a typical dermatitis, resembling that of the primula plants, appearing on the hands, wrists, face and neck, but not affecting the conjunctiva, mouth or penis. The effect is first felt at the place of contact, but soon spreads widely. Sensations of heat, weight and stinging pain arise, mainly when inflammation is considerable. The skin becomes moist and desquamates and the itching is intermittent. First attacks are slow at the onset, but sharp relapses are of frequent occurrence. The after-effects are to produce a long-continued susceptibility of the nervous system to bodies which normally would have little or no irritating effect.

Immunity to the irritant varies. Some individuals show complete indifference, others show a more or less primary dermatitis, but after recovering are able to resume work in satinwood dust without further inconvenience, while still others suffer an immediate relapse when again brought into contact with the dust and are permanently unable to continue work in it. Toward this latter class of individuals, subsequent contacts are markedly more severe in their results.

The solution of the satinwood poisoning problem is the same as in the case of poisoning by cocobolo and other woods, namely, the securing of an immune working force to handle the wood in the stages in which dust is set free.

TEAK

Teak, the product of *Tectona grandis,* is imported into the United States from India, Burma, Siam, and Java. The wood, dark-brown in color and often marked with blackish streaks and veins, is moderately hard and strong and straight-grained. It possesses an essential oil that fills the pores of the wood and makes it extremely durable. Teak is resistant to the attacks of insects and to the action of fire, water, and rust.

Its reputation for indestructible permanence led to the employment of teak in the building of Indian temples thousands of year ago and wood has been found well preserved in temples in Salsette and elsewhere in western India that have been standing for over two thousand years. In that country, teak is now used extensively for furniture and buildings. In the United States it is used to considerable extent, finding a demand in ship-building, where it is used for finish, outside companionways, rails and seats, and in the manufacturing of furniture, interior finish of buildings and Pullman parlor and sleeping cars, flooring, parquetry and athletic goods.

An irritant resin is present in teakwood and the dust when finely pulverized, and inhaled or swallowed, may give rise to nausea, vomiting and other constitutional symptoms. Locally it produces a severe, generalized and very persistent dermatitis which may not be relieved for many weeks, meanwhile causing intense burning and itching of the skin.

COCUS-WOOD OR GREEN EBONY

Brya ebenus yields a wood known to the trade under a variety of names, the most common of which are brown or West Indian ebony, coco, cocus, granadilla, torchwood, greenheart ebony, and green ebony. The tree producing this wood grows sparingly on some of the islands of the West Indies and on the mainland from Mexico southward to Colombia and Venezuela.

The wood is deep green to brown in color, very hard, heavy, strong and tough and susceptible of a high polish. A water-insoluble resin, present in the wood, renders it very durable and inflammable. Because of this latter characteristic it is employed by the natives in the West Indies for torches; hence the name torchwood. In this country it is used for inlaying, musical instruments, brush and mirror-backs, tool and knife handles, rulers, jewelry boxes, walking sticks, umbrella handles, riding whips, pin trays, picture moldings, and small articles of furniture. It is much in demand for flutes and turnery of all kinds.

The presence of an irritant oil in the wood may result in a papular eczema of the lips and ears and sometimes may involve almost the entire face.

SABICU WOOD

Sabicu wood, *Lysiloma sabicu*, a product of the West Indies, is a highly figured wood, bearing a rather close resemblance to mahogany. It is somewhat in demand in fine cabinet work, for which the exceeding smoothness of the grain makes it particularly suitable. In England the wood has been used in ship-building, for gun carriages and similar work, and for saddle trees. It is also used in the manufacture of shuttles.

Sabicu is said to produce a "snuffy dust" resulting in catarrhal symptoms of the eyes and nose.

INDIAN ROSEWOOD

Reference is found in a German publication to the fact that the dust from Indian rosewood resulted in intense itching of the hands and face

of employees in a Vienna store-fixture factory. This wood is probably the product of *Dalbergia latifolia*, of India, also known as East Indian rosewood or blackwood, the wood of which is very hard, heavy, strong and tough, taking a very good finish. It is used extensively for cabinet work, boat and ship-building, agricultural implements and construction.

MOA WOOD

From Germany comes the report of an Australian wood, the product of a species of *Eucalyptus* known to the trade as moa wood or black butt, which exhibits pronounced toxic properties. On account of its very high cost, moa wood is not in general use, but as it assumes a splendid color when polished it is sometimes used in wainscoting parlors of luxurious passenger steamers.

A toxic principle, reported to be a crystalline alkaloid, is contained in the wood and may cause an itching eruption which spreads over the body. Some individuals develop an immunity after being subjected to the disease, while others retain an extreme hypersensitiveness and are no longer able to work with the wood.

TAGAYASAN

Tagayasan, or tagasaya, is a Japanese wood much used in making fine furniture, because of its hardness, fine appearance and property of finishing well. In working the wood a dark-brown or violet, highly irritant dust arises.

This dust produces serious disturbances of the rental and digestive functions and results in intense inflammation of the eyes and the skin of the hands, and faces of the workmen, causing a dark-brown discoloration having the appearance of gunpowder pigmentation. The wood contains a substance chemically allied to chrysarobin, a skin irritant, the use of which is well known in medicine.

OTHER TROPICAL WOODS

A number of other tropical woods are reported to have a toxic effect on the human body. Among them are the following:

Ebony—sometimes causing inflammation of the skin.
Borneo rosewood—resulting in some cases in eczematous eruptions.
Magenta rosewood—having irritating effects.
Olive wood—causing illness to some persons.
Mahogany—inflaming the membrane of the eyes and nose in certain instances.

Brazilian peroba.
Mexican blue gum.
Partridge wood.

There are two other woods used in the United States, which, while not toxic in their action, contain rather interesting principles. They are bethabara and tonquin.

BETHABARA

Bethabara is a copyrighted name applied to a Dutch Guiana wood now imported into the United States chiefly for making fishing rods. It is the product of a species of *Tecoma* and is known in the region in which it grows as washiba, wasiba or bow-wood. The exact distribution of the tree is not known, but it is quite likely that it grows also in Venezuela, Brazil and British and French Guiana.

The wood is olive-colored, exceedingly hard and heavy, tough, elastic, and works with difficulty. It is extremely durable in contact with soil and is frequently employed in Dutch Guiana for fence posts, telegraph poles, and foundations of houses and, in fact, for anything in which great strength, hardness and durability are required.

A yellowish crystalline substance, known as Lapachol, is extracted from the wood by alkaline solutions and turned to a bright red color by the action of potash. Some handlers of the wood have been using the shavings and sawdust of bethabara for staining purposes for a number of years. In this connection, wood turners working at the lathe have been known to attempt to wash the white sawdust out of their hair only to have the hair turned almost red by the action of soap.

TONQUIN

Tonquin, the product of *Dipterix odorata* of British Guiana, is also known as cuamara and tonga-bean. A hard, heavy and exceedingly strong wood, taking a fine polish, it is imported into the United States and made into veneer for use in furniture and in the finishing of Pullman parlor and sleeping cars.

"The Occupational Diseases," by W. G. Thompson, contains the following reference to tonquin: "On being sawed into thin slabs, it gave off a most unusual quantity of bright red sawdust which covered the workmen. One of them, thinking to wash the dust from his hair, dipped his head in a bucket of water, when, to his surprise, the hair turned a bright grass-green color. It took him several days of scrubbing to restore the natural color."

It is quite possible that this wood contains a crystalline substance, similar to that in bethabara. It does not seem, however, that such a marked change in color as is described in the foregoing paragraph could be brought about by the action of water alone and it is probable that soap or some other substance was present.

SOIL ACIDITY PREFERENCES OF SOME EASTERN CONIFERS

By Edgar T. Wherry

United States Department of Agriculture

The importance of the reaction—that is, the acidity or alkalinity—of the soil in connection with the growth and distribution of plants has in recent years come to be recognized by many ecologists.[1] In the course of studies of the soil reaction preferences of shrubs and herbaceous plants, the writer has had opportunity to make a number of observations on coniferous trees, and although the data are not as full as might be desired, so much interest in them has been shown by ecologists and foresters with whom the subject has been discussed that they are here placed on record.

The nature and origin of soil acidity have been explained in detail in the papers cited, and it need only be noted here that while the acidity is never sufficiently great to yield a sour taste, it, as well as the alkalinity, can be determined quantitatively by the use of indicators, or reaction-sensitive dyes. A small soil sample is stirred up with a little pure water, allowed to settle, and a portion of the clear extract tested with each of a series of these indicators, the degree of acidity or alkalinity being shown by the colors they assume.

Physical chemists are accustomed to state active acidity data in reciprocal logarithms, the so-called P_H or pH values; but the writer has urged, in the papers cited, that a more readily understandable method be used. This is, in brief, to take as a unit the rounded off amount of active acid or alkali present in pure water—for minute, equivalent, quantities of both are actually existent therein—and to express all other data in terms of this unit. Just as the weight of a substance referred to water as a unit is termed specific gravity, so the reaction

[1] Experiments in blueberry culture, 1910, by Frederick V. Coville. U. S. Dept. Agr. Bull. 193.

Oecologische Studien in den Stockholmer Schaeren, by O. Arrhenius. Stockholm, 1920.

Studier over Jordbundens Brintionenkoncentration og dens betydning for vegetationen, etc., by Carsten Olsen. Copenhagen, 1921.

Soil acidity and a field method for its measurement, by Edgar T. Wherry. Ecology, vol. I, 1920, p. 160. Reprinted with abstracts of other papers in Smithsonian Report for 1920. 1922.

values thus derived may be termed specific acidity and specific alkalinity. It is also convenient to have a series of roughly quantitative terms to refer to certain commonly encountered ranges of specific reaction, and the following have been suggested: Superacid, specific acidity greater than 1,000; mediacid, between 1,000 and 100; subacid, between 100 and 10; minimacid, between 10 and 1. On the alkaline side corresponding terms are used. A neutral reaction is described alike by specific acidity 1 and specific alkalinity 1; and the slight activity represented by values between specific acidity 10 and specific alkalinity 10 is covered by the term circumneutral.

Plants differ markedly in their response to acidity or alkalinity of the soil, some being apparently able to grow about equally well no matter what the reaction, while others are very sensitive in this respect, and die promptly when placed in a soil of unsuitable reaction. In the articles above cited the soil preferences of a number of herbs and shrubs have been recorded, but trees have not been specially considered. This is largely because of the greater extent of their root systems, which renders their soil acidity preferences more difficult to ascertain than are those of the smaller plants. The seeds of trees lodge and germinate in the upper layers of the soil, and so are affected only by the acidity conditions existing there; but as soon as the roots reach any considerable length, they may be subjected to totally different reactions. Since soil acidity is largely the result of the oxidation of cellulose and other constituents of the leaf litter, it is normally greatest at the surface and diminishes more or less rapidly in depth. Moreover, the leaching effect of rain, removing lime and other bases which might neutralize the acids as fast as they form, is greatest at the surface.[2] In studying the soil acidity relations of trees it is therefore essential to note not only the surface acidity, but also that at some depth, so that an idea of what may be termed the acidity gradient can be obtained; and as the writer's work has progressed, this has been done more and more. It turns out that three general habitat classes can be recognized, which may be termed respectively acid, intermediate, and circumneutral.

Acid habitats comprise such as exist, for instance, in the New Jersey pine barrens, where the surface soil is mediacid (specific acidity 1,000 to 100) over vast expanses. Here the acidity gradient is slight and at

[2] O. Arrhenius, loc. cit. Stratification and hydrogen ion concentration of the soil * * * with special reference to woodlands, by E. J. Salisbury. Journ. Ecology, vol. IX, Feb. 1922, p. 220.

depths of a meter the reaction may still be mediacid, or at any rate subacid. In some peat bogs, also classed as acid habitats, the acidity even increases slightly with depth, owing to the production of acids from the peat under anaerobic conditions.

Intermediate habitats may be superficially similar to the preceding, with mediacid reactions at the surface, but the acidity gradient is marked, and the acidity is decidedly lower at 10 cm. depths, while the soil is usually quite neutral before the depth of a meter is reached.

Circumneutral habitats are those in which the surface material is only exceptionally more than minimacid. The surface may be neutral or even somewhat alkaline, and in any case minimalkaline reactions are shown within a few centimeters of the surface. In regions underlain by limestone the relations are usually of this type.

There are of course all gradations between these classes, yet assignment of a given habitat to one or the other is usually not difficult. In using the data here recorded, however, it must be remembered that they are based for the most part on a somewhat limited number of observations in the Eastern States only, and it is not improbable that further studies may indicate other preferences for some of the species included.

The data as to individual species are presented in four tables, with discussion of special features following each. The technical nomenclature of Gray's Manual, seventh edition, is followed, while the common names given are those most used by foresters. In order to bring out what correlation there may be between soil reaction and geographic distribution, the tables include a column of letters referring to the several provinces which are worth recognizing for the purposes of this study. Beginning at the coast and passing inland and northward, these are: C for Coastal Plain, P for Piedmont Plateau, S for southern Appalachian mountains, A for Appalachian mountains in general, and N for the northern, glaciated part of the continent.

TABLE 1.—*Conifers Preferring Acid Habitats (Though Also Found in Intermediate Ones).*

Name	Provinces	Studied in
Pinus palustris	C (P)	Central Georgia.
Pinus rigida	C (P, A, N)	North Carolina to northern New York.
Pinus pungens	A (P)	North Carolina to Pennsylvania.
Pinus banksiana	N	Northern Indiana.
Picea rubra	A (N)	West Virginia to Pennsylvania.
Picea mariana	N (A)	Northern New England.
Abies fraseri	S (A)	North Carolina.
Chamaecyparis thyoides	C (N)	Virginia to New Jersey.

The long-leaf pine, *Pinus palustris* Mill., has been studied only in central Georgia, where the habitat proved to be typically acid, measurements in road and railroad cuts showing uniform mediacid reaction from the sandy surface to depths of over 3 meters in the mottled clay subsoil.

The pitch pine, *Pinus rigida* Mill., is especially characteristic of the acid New Jersey pine barrens. Less commonly it grows in clayey or sandy soils where neutrality is reached at moderate depths, as in the vicinity of Washington, D. C.

The table-mountain pine, *Pinus pungens* Lamb., is one of the most acid-loving species observed, growing by preference on sandstone ledges where the rock constituents are too insoluble to neutralize the acids formed by the decomposition of its needles.

The writer's only observations on the jack pine, *Pinus Banksiana* Lamb., have been made in the sand dune region of northern Indiana, along the shore of Lake Michigan. The sand here is largely derived from glacial drift rich in grains of limestone, and except where extensively leached the soil has a neutral reaction. Seeds of the pine falling into this neutral material are able to germinate; then, as soon as the young trees reach any considerable size acid substances are produced on their bark, and the rain washes these down in sufficient quantity to acidify the sand beneath to depths of at least 10 cm. Below that, the acidity diminishes, and the conditions are therefore intermediate as above defined. However, this tree does not reach its maximum development in that region, and the data of Fernald [3] and of Pease [4] clearly indicate that it thrives best in acid habitats.

The red spruce, *Picea rubra* Dietr., and the black spruce, *P. mariana* B. S. P., have both been observed on rocky slopes where conditions were acid to intermediate, as well as in sphagnum swamps with all their roots in the mediacid peat.

The Fraser fir, *Abies fraseri* Poir., has been tested only in the high mountains of North Carolina, where it grows on sandstone ledges incapable of neutralizing the acids produced from its needles, the habitat being thus an acid one. The region in West Virginia where the same species is now known to grow [5] has been found to include much acid soil, although no tests have been made at the roots of the tree itself.

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[3] Rhodora, vol. XXI, 1919, p. 57.

[4] Rhodora, vol. XXIII, 1921, p. 247.

[5] West Virginia Trees, by A. B. Brooks. Bull. Agr. Expt. Sta. W. Va. Univ. No. 175, 1921, p. 45.

The southern white cedar, *Chamaecyparis thyoides* B. S. P., appears to be strictly limited to acid habitats. It is abundant in wet places in the New Jersey pine barrens and at depths of a meter its soils show no diminution from the mediacid surface reaction. In the Dismal Swamp in Virginia it frequently grows in pure stands, and borings to depths of as much as 5 meters showed practically no decrease from the same high surface acidity. By way of contrast, similar borings where water gum (chiefly *Nyssa biflora*) is the dominant tree showed a marked gradient, the underlying mineral soil being calcareous and tending to neutralize the acidity of the peat adjoining it. The patchy distribution of these two types of forest appears, then, to be less a matter of succession than one of control of vegetation by the chemical nature of the mineral soil. After the timber has been cut from the swamp, there is therefore good reason to suppose that both gum and cedar forests will again develop at about the same places where they now exist.

TABLE 2.—*Conifers Preferring Intermediate Habitats (Though Also Found in Acid Ones).*

Name	Provinces	Studied in
Pinus taeda	C (P)	Georgia to Delaware.
Pinus serotina	C	Georgia to Delaware.
Pinus echinata	P (C)	Georgia to New Jersey.
Pinus resinosa	N	New York, Vermont, and Ontario.
Abies balsamea	N (A)	Northern New England.
Tsuga caroliniana	S	North Carolina.

The loblolly pine, *Pinus Taeda* L., has been found to grow mostly in sandy or clayey soils which are usually mediacid at the surface but exhibit a marked gradient and become neutral at moderate depths. In the Piedmont region of Georgia, however, this species is apparently unable to compete successfully with the yellow pine on such intermediate soils, and tends to spread into acid places where it mingles with the long leaf pine.

In the swamps of central Georgia, where the pond pine, *Pinus serotina* Michx., is relatively abundant, the soil conditions range from intermediate to acid. In its northeastern extensions into Delaware—where it has been found by the writer near Millsboro—and New Jersey,[6] the relations are identical.

The yellow pine, *Pinus echinata* Mill., grows to some extent in acid habitats, but reaches its best development in the Piedmont region of the Southern States, where conditions are intermediate.

[6] The plants of southern New Jersey, by Witmer Stone, Trenton, 1910, p. 149.

In many places north of the terminal moraine the glacial till includes so many fragments of calcareous rocks that its soils are dominantly circumneutral. Here and there, however, leaching of lime has taken place to such an extent that intermediate or even acid conditions have developed. It is in the last two sorts of locations that the writer has found the red pine, *Pinus resinosa* Ait. Except that it also often grows in acid sphagnum swamps, the balsam fir, *Abies balsamea* Mill., shows essentially similar relations.

The southern hemlock, *Tsuga caroliniana* Engelm., has been observed to grow in the North Carolina mountains chiefly in intermediate ravines, but occasionally it extends up into acid sandstone ledge situations.

TABLE 3.—*Conifers Preferring Intermediate Habitats (Though Also Found in Circumneutral Ones).*

Name	Provinces	Studied in
Pinus virginiana	P (A, C)	Alabama to Pennsylvania.
Pinus strobus	A (P, N)	North Carolina to New York.
Taxodium distichum	C	Mississippi to Delaware.
Juniperus communis var. depressa	N (P)	Pennsylvania to northern New England.
Tsuga canadensis	A (P)	North Carolina to New York.
Taxus canadensis	N (A, P)	Pennsylvania to New York.

While pines are commonly regarded as indicating barren, and therefore presumably acid, soils, the different species are not of equal significance as soil indicators. The scrub pine, *Pinus virginiana* Mill., for instance, does not thrive in the New Jersey pine barrens, but in that State is at its best in the less acid soils of the marl area. It also grows in non-acid clays, and in the Piedmont of Virginia has even been noted on limestone ledges, where the reaction is typically circumneutral.

The white pine, *Pinus strobus* L., does not appear to colonize either habitats of high acidity or rich black alkaline soils of calcareous regions. It is most abundant in typically intermediate habitats, though also found on limestone ledges and in other circumneutral situations.

It is difficult to classify the bald cypress, *Taxodium distichum* Rich., for it occurs in habitats of rather diverse chemical character. In the southwestern part of its range it often grows in limestone regions, where the surface water may have a distinctly alkaline reaction, bringing it into the circumneutral class. Toward the northeast, on the other hand, the surface material is mediacid, the brown fibrous peat and coffee-colored water associated with such reactions being often

observed in cypress swamps. Borings usually show, however, that neutral soils are within reach of its lower roots, so intermediate classification is indicated. The pond cypress, *Taxodium ascendens,* shows in southeastern Virginia the latter relation.

The ground juniper, *Juniperus communis* var. *depressa* Pursh, is usually recorded as not occurring south of New York, but there are colonies of it well known to loçal botanists and nurserymen in the vicinity of Harrisburg and Lancaster,[7] Pennsylvania, and tests at these localities have shown conditions to be circumneutral, the underlying rock being limestone. It is much more abundant in glacial till in northern New England, where conditions are often intermediate.

The needles and more especially the bark of the hemlock, *Tsuga canadensis* Carr., are decidedly acid in reaction, so that the surface soil under hemlock trees is usually well acidified, and can be used in making up garden beds for the cultivation of acid soil plants. Beneath the surface layers, however, the reaction almost always approaches neutrality, and sometimes the lime may reach the surface and produce circumneutral conditions.

The ground hemlock, *Taxus canadensis* Marsh, has such shallow roots that only the surface soil need be tested in classifying it. It appears to thrive best in subacid material, though occasionally found in neutral rock fragments.

TABLE 4.—*Conifers Preferring Circumneutral Habitats (Though Also Found in Intermediate Ones).*

Name	Provinces	Studied in
Larix laricina	N (A)	Indiana to New Jersey and New England.
Thuja occidentalis	N (A)	Virginia to New England.
Juniperus virginiana	P (C, A, N)	Tennessee to New Jersey.

The southern limit of the tamarack, *Larix laricina* Koch, is usually stated to be northern Pennsylvania, but it is now known to extend as far south as Preston County, West Virginia,[8] a region where the swamp soils are often intermediate. Farther north, however, the writer's tests have indicated this tree to thrive best where the conditions are circumneutral. The heaps of needles directly under the trees may attain so high a degree of acidity that the stemless slipper orchid, *Cyripedium acaule* Ait., will grow in them, but at their bases the material is usually neutral, and the water in the depres-

[7] See article in American Forestry, vol. XXVIII, 1922, p. 164.
[8] A. B. Brooks, op. cit., p. 39.

sions may be actually minimalkaline. In such situations it has been noted that the water dripping from the branches is slightly alkaline also, evidently owing to the roots having absorbed more lime than the plant needed, and to elimination of the excess by excretion through the leaves. In some tamarack swamps the conditions may be more acid, and in one instance the specific acidity of 1,000 has been observed at the roots of this tree,[9] so that its acidity range is unusually wide.

The distribution of the arbor vitae, *Thuja occidentalis* L., has been shown by Fernald[10] to be dominantly controlled by what are termed in this paper circumneutral conditions. This has been confirmed by the writer by actual tests both upon the enormous trees growing on limestone ledges in the mountain valleys of southwestern Virginia and in New England. When it spreads into intermediate habitats it does not appear to reach its maximum development, although in cultivation it seems to give satisfaction when planted along with rhododendrons in subacid soils.

The red cedar, *Juniperus virginiana* L., reaches its maximum development in the limestone barrens of Tennessee, where the surface soil is minimalkaline, and the habitat typically circumneutral. It is also abundant in many other limestone regions, where conditions are similar. In fact, this tree becomes prominent on basic igneous rocks, calcareous clays, and various other substrata in which lime is present in available form within reach of the surface.

DISCUSSION

Of the twenty-three species and varieties of conifers studied[11] more than half seem to favor the more acid conditions. However, enough thrive in the more neutral or alkaline habitats to show that it is unsafe to use the presence of abundant conifers as an index of acidity or of agricultural barrenness of the soil in a given locality. In this connection it is interesting to note that most pines and their relatives are to be found in the acid groups, while the cedars, etc., (by some botanists placed in a separate family, the *Juniperaceae*), are more abundant in the neutral or alkaline ones.

[9] F. V. Emerson, Bot. Gaz., vol. LXXII, 1921, p. 359.

[10] M. L. Fernald, Rhodora, vol. XXI, 1919, p. 57. Also Pease, vol. XXII, 1920, p. 41.

[11] The following listed in Gray have not been available for test: *Picea canadensis, Juniperus communis, J. communis* var. *montana*, and *J. horizontalis*.

Looking at the relations in another way, the species dominant in the southern and coastward provinces are more numerous in the acid groups, the northern species in the neutral-alkaline groups. The latter relationship has been pointed out by the writer (in the papers above cited) to exist also in certain other groups of plants, such as the ferns and the orchids.

The importance of the application of such soil acidity data to the solution of problems in forest distribution, natural regeneration, and artificial reforestation is evident. When the humus layer has been destroyed or altered by exposure to light incident to the removal of the timber, or by burning over, the chemical character of the surface soil—which may be more acid or more alkaline than the original humus, depending on circumstances—will have most to do with determining what sort of new growth will come up, or whether efforts to reproduce the former forest cover will be likely to succeed. However, much more data is needed, and it is hoped that others interested in forestry problems will take up the observation of the soil acidity preferences of our trees, on a more extensive scale than has been possible in this preliminary study.

REPRODUCTION AND NITROGEN

By E. N. Munns,

Forest Examiner, U. S. Forest Service

Following a fire after logging on the Stanislaus National Forest, very little vegetation reclaimed the ground, showing the fire to have been exceptionally severe. Very little reproduction has come in in spite of the fact that there are occasional seed trees of incense cedar and western yellow pine fairly uniformly distributed over the burn. A careful search revealed that there was no reproduction on the ground save that secured in the spring of 1913 from the 1912 crop, which though light was followed by one of the most favorable seed years experienced in California.

On this burn was one patch of about three-fourths of an acre in which the lupine (*L. grayii*) was exceedingly abundant, in fact it made a patch of continuous ground cover with very few openings and made up fully 95 per cent of the total herbaceous and woody plants on this area. It was noted that the reproduction found in this small area of lupine was noticeably larger than that in the surrounding ground, on which there was very little and scattered ground cover—chiefly of annuals—though there were scattered individuals of buck-brush (*C. cordulatus*) and blue-brush (*C. integerrimus.*) As the difference in growth on the two areas was so marked measurements were made of the very best trees found in the adjoining area not inhabited by the lupine, and on the trees which grew in the lupine itself. Growth was measured between each node, beginning with that of the 1920 season and counting back to the ground in each case. It was found that the yellow pines in the lupine made a much greater annual growth than those out in the open ground or among the other vegetation, and that the total difference between the two amounted to nearly 2 feet. The averages of twenty-three trees in the lupine area and of thirty-seven of the very best trees in the adjoining patch of ground are given in the following table.

It is to be noted that in the first three years there was very little difference in the height growth of the trees within the lupine and those without, while beginning in the fourth year comes a difference

Yellow Pine. Growth During Year in Inches.

	1920	1919	1918	1917	1916	1915	1914	1913	Total
Lupine	21	16	17	13	13	8	7	5	99
Other ground cover.	14	12	12	10	9	7	7	5	76
Excess	7	4	5	3	4	1	0	0	23

of 4 inches, which increases to 7 inches for the year 1920, with a total growth of 99 inches in the lupine as against 76 outside—a difference of 23 inches. The maximum growth of a pine in any one year in the lupine amounted to 28 inches while the maximum growth in one year of the best tree in the outside adjoining ground only amounted to 21 inches.

The only explanation that can be given for the marked difference in the rate of growth of these seedlings is that the nitrogen forming bacteria on the roots of the lupine so increase the fertility of the ground that the resulting tree growth was very much augmented. It would also appear from the increased growth beginning in 1916 that the lupine did not get firmly established or spread over the ground until about 1915. At the present time the nitrogen producing capacity of the lupine appears to be at a maximum. The writer does not believe there is any other explanation for this other than the increased fertilization of the soil, as to all appearances the soil inhabited by the lupine and that outside this area was exceedingly similar, being a very deep and porous granitic loam such as is common throughout wide stretches of the high pleateau of the Sierra region. The difference in growth can not be due to moisture since the heavier plant cover was found in the lupine area as against a lighter cover on adjoining ground.

Similar results have been obtained in forest nursery practice, for by using red clover as a cover crop in the transplant beds, heavier and stockier plants of yellow and jeffrey pine have been produced.

Additional observations of such phenomena are clearly required, for it may be that by using nitrogenous plants in forest plantations we may be able to so increase the rate of growth that it would more than pay for the additional cost and labor in starting them.

AN EFFECTIVE FOREST FIRE ORGANIZATION

By Geo. H. Wirt

Chief of Protection, Pennsylvania Department of Forestry

There is little virgin timber left in Pennsylvania. Consequently the virgin forest need not be considered in any discussion of future forest needs in this State. There are some areas where conifers predominate and some where conifers are mixed with hardwoods, but the greater part of the present forest area is covered with hardwood growth or will be covered by hardwoods.

In the removal of the virgin forests during the last 50 years and in the cutting of succeeding growth a wide variety of methods of harvesting has been used. The whole gamut from wasteful logging to the closest utilization, from no attention to slash to careful and very expensive slash disposal has been run. Unquestionably there has been an unconscious application of many methods of regeneration and management ranging from the simplest selection system to the cleanest clear cutting system. Still the remarkable fact is that wherever one finds valuable tree growth today in Pennsylvania the reason for its existence is not the method of lumbering which may have been conducted upon the area, but rather the fact that the area has been kept free from fire. Likewise, with perhaps very few exceptions, wherever one finds no valuable tree growth on land not previously cleared for cultural purposes the reason for its condition is not so much wasteful and unwise methods of harvesting the crop as lack of protection from fire.

In spite of little or no reasonable consideration upon the part of man for the reproduction of a crop of forest growth, nature has proved that where fire is kept out continuous forest production is possible under practically all Pennsylvania forest conditions. Needless to say, the crop so produced is not what may be expected under careful management. Nor is a verification and knowledge of these facts any excuse for wasteful methods under conditions which make close utilization financially profitable. Nor should the fact be overlooked that natural regeneration even with protection from fire will not be sufficient to produce the highest possible forest yields or meet the future

timber needs of Pennsylvania citizens. But from a consideration of minimum needs to insure continuous forest production as good or better in volume than that of the past, protection from fire is the essential factor, rather than method of cut and artificial provision for reproduction.

Pennsylvania has approximately 13 million acres of forest land. It is well distributed, not bunched in one or several large tracts or uninhabited or sparsely settled regions. The 10 million people of the State are also well scattered in and near the forest areas. Thousands of miles of roadways. Many industries of the State are located in or near forests. The streams of the State are fished in spring by thousands of people and a million people hunt in the forests in fall. Practically every acre of forest land, therefore, is exposed to one or more fire risks during both spring and fall forest fire seasons, in fact during the entire year.

Under such conditions it must be remembered that every square foot of forest area in Pennsylvania constitutes in itself, whether in its most natural or in its most satisfactory artificial sylvicultural condition, a forest fire hazard on every day in the year when it is not actually raining or when there is no snow on the ground. It is the dead leaf litter, dead grass, bracken, or other low herbaceous material, which upon becoming dry under action of sun and wind, catches the spark from passing or nearby engine, from the unguarded brush or camp fire, from the discarded smoking material, or other source of fire. Any other material on the ground is simply added fuel to the fire.

It is this same leaf litter which is the essential factor in continuous forest production, and in the forest's beneficial influence upon moisture conditions. It has been proved time after time that continuous removal of the leaf litter results in the destruction of the forest. Therefore it is essential to bear in mind that without regard to the effect of fire upon existing growth no matter what its age or susceptibility to injury by fire, the important thing is to prevent the destruction of the forest litter and all it holds.

The seasons of year which normally produce conditions of greatest forest fire danger in Pennsylvania are spring and fall during the months of March, April, May, October, and November. But with the development of a more efficient organization and consequently of a more nearly complete record of all fires which occur, it is found that under certain combinations of weather factors, forest fires occur each month of the year.

All of these facts, supported by past experience indicate conclusively the necessity of a protective organization with a permanent nucleus of men, plus an additional force employed full time during at least five months in the year, plus an additional emergency organization. And to make the necessary protective organization efficient there must be also permanent and temporary equipment.

In Pennsylvania the permanent nucleus is made up of 23 district foresters, 12 assistant foresters, and 76 State forest rangers. Twenty-one of the 24 forest districts into which the State is divided have State forests within them. The semi-permanent force is made of towermen, inspectors, fire bosses, and patrolmen. The emergency force is composed of the local forest fire wardens who may call upon any one for assistance.

Necessarily the units of the organization are placed according to the present varying factors of risk and of forest conditions. There will be some variation from season to season and from year to year. In the fall of 1921 there were in service 39 inspectors, 64 towermen, 206 fire bosses and approximately 2,500 other forest fire wardens.

In the spring of 1922 there will be 53 inspectors, 81 towers manned, 18 patrolmen and 360 fire bosses.

The organization as planned is centered not only around the district forester, but it is closely tied up with the tower system. Patrol as formerly used will be abolished since it has proved to be in most instances inefficient and costly. The present organization will insure prompt detection and extinction of fires, inspection and elimination of hazards, fixed responsibility, pay commensurate with service rendered, and public education.

Each forest district is to be divided by the district forester into several areas, depending upon its size, the nature of the country, and the likelihood of fires occurring. In general, the areas should contain from 50,000 to 150,000 acres of forest land. Each area will be in charge of an inspector. The inspector may be the Forester's assistant, a ranger, or a specially employed man, who will be responsible to the district forester for the satisfactory protection of the area.

INSPECTORS

The position of inspector meets a long-felt need for a man who will have active and detailed supervision over a comparatively limited area, make inspections of hazards, make investigations of fires, and have constant check on the work of towermen, fire bosses, and wardens.

The inspector will be the right-hand man of the district forester in the area allotted to him, and will be in immediate charge of the fire situation in that territory. He must be capable of making a good impression on the people with whom he comes in contact, honest, hard working and impartial. He must be a good fighter and organizer, and must be capable of making investigations into the causes of fires. He must have some means of conveyance of his own, a horse, automobile or motorcycle, and should have telephone communication. His activities will in general be confined to private land, except where a State forest ranger is detailed for this duty. Preference shall be given in appointments to the best of the present wardens if suited for the work or if they can serve. He is not a patrolman and shall not be used for that purpose. His duties will be to:

A.—Inspect: (1) all sawmills; (2) railroads; (3) roads; (4) other hazardous conditions.

B.—See to it that the fire organization is in order at all times to meet any emergency, report to district forester all indications of inefficiency, and make recommendations for improvement of the organization.

C.—Have direct charge of the fire warden in the area assigned to him and to keep them alive to the need for prompt action when their services are needed.

D.—Keep in touch with the towermen.

E.—Take charge of any fire on which he is needed, especially in case the warden immediately in charge needs additional help.

F.—Investigate all fires in his territory.

G.—Check up on all fire fighting equipment in the hands of fire bosses, its use and condition.

H.—Visit schools.

I.—Put up posters.

J.—Make a semi-monthly report to the district forester on Form 34 setting forth his (1) activities for the period; (2) recommendations for the betterment of the organization.

He will be paid a salary for the fire season. He must be a fire warden but will not be paid extra for fire fighting.

TOWERMEN

A towerman shall be in charge of his tower and shall be responsible for its condition. He must be reliable, energetic, have good eyesight, and must be capable of reading and understanding maps. He must know his region thoroughly. He must have knowledge of the general behavior of fires and must be capable of exercising good judgment in the reporting of them. He must be courteous and must be able to

talk intelligently about the protective organization in the territory under his observation. He must be neat. Rangers shall *not* be used regularly as towermen. The towerman must be a forest fire warden and present wardens who are satisfactory must be given preference in appointment.

The towerman shall be responsible for the prompt detection and reporting of all fires that occur on the area under his observation and his duties will be to:

A.—Report all fires to the fire boss nearest the scene of the fire, giving the (1) location and extent as accurately as possible; (2) direction the fire is burning; (3) approximate number of men necessary to promptly extinguish it; (4) apparent cause.

B.—Keep the district forester and inspector informed as to the progress of all fires and report the need of additional help.

C.—Keep the telephone line to the tower in repair.

D.—Maintain everything in and around the cabin and tower in a neat and cleanly condition.

E.—Do such other work that may be assigned to him during wet weather.

F.—Make a *daily* report by telephone to the district forester during dangerous seasons.

G.—Make a semi-monthly report in duplicate to the district forester on Form 36.

FIRE BOSSES

Fire bosses and their crews will constitute the mainstays of the extinction forces.

The fire bosses shall be the best fire wardens situated in the most advantageous places for the prompt extinction of fires and should be men who are comparatively independent, such as farmers, storekeepers, etc. Most State forest rangers may be detailed for this duty. A fire boss must be honest, reliable, energetic, a good fire fighter and organizer. He *must* have a telephone either in his home or one close by that is available for his use at all times. He must appreciate the value of minutes in fire extinction. He *shall not* be used for patrol duty. The duties of a fire boss will be to:

A.—Organize and maintain an efficient crew of fire fighters that will be willing to answer a fire call at all times or, if necessary, several crews.

B.—Remain at his station during all periods when there is danger of fires occurring.

C.—Respond to all fire calls promptly.

D.—Have charge of the crew at the fire.

E.—Have charge of the fire in the absence of the inspector and to promptly and efficiently extinguish it.

F.—Report on Form 15 all fires he helps to extinguish.

G.—Render a correct statement of the expenses in connection with the extinction of fires.

H.—Use properly and keep in good condition all fire-fighting tools placed in his care.

I.—Investigate, under the direction of the inspector, the causes of the fires he extinguishes.

J.—Keep in touch with the inspector and call upon him or upon the towerman for assistance.

K.—Submit to the district forester and the inspector a list of his crew as soon as it is organized.

By having the fire boss submit the names of the members of his crew a complete record of personnel is had and a check provided for the district forester in auditing the fire bills.

He shall be paid a small salary, $10 to $20 per month, during the fire season and in addition 50 cents an hour for time actually engaged in extinguishing fire, including time going to and from fires. The small salary will serve as a retainer fee and promote more active interest in the work.

FIRE CREWS

Fire crews shall be made up of reliable men who are good fire fighters and are interested in the prevention and extinction of fires.

Small regular crews (six to eight men) can be better trained, organized, equipped, and transported than larger ones. The monetary inducement to join a crew will be the higher wage rate than is to be paid to men not members of crews.

They shall be willing to go to a fire at any time they are called by the fire bosses. The crew is under command of the fire box, and is responsible for the prompt and efficient extinction of all fires.

Regular crews shall be paid a rate higher than the ordinary untrained fire fighters but shall not receive more than 40 cents an hour.

PATROLMEN

Patrolmen *shall not* be employed except in cases of emergency as to time and hazard and only when authorized by the chief forest fire warden. Their qualifications are the same as those of fire bosses.

A patrolman's duties shall be specific and be assigned to him by the district forester. He shall be under the immediate supervision of the inspector.

He shall be paid an hourly wage for the time actually employed.

WARDENS

The qualifications of wardens remain as at present. They will constitute the reserve force of the organization and may be called upon at any time to assist in the extinction of fires. They will be directly under the supervision of the inspectors. Everything possible must be done to keep up the morale of this volunteer force but by a proper development of the organization now planned the less desirable of the present wardens can be dropped.

Wages of wardens must not exceed 50 cents per hour, but ought not to be as high as those of the fire bosses in the same community.

Assuming that every acre of forest land must be protected, that all fires must be detected within five minutes after they start, that they will be reported within five minutes after detection, that they will be extinguished within two hours after being reported to a district forester, inspector, or fire boss, it is safe to assume that no fire will burn over more than 100 acres, that the average will be 10 or fewer acres and that the total area burned over in any one year will not exceed 20,000 acres. That is the goal set for the Pennsylvania forest fire organization and the basis upon which it is being planned.

The annual expenditure needed to maintain an organization to accomplish such results is as follows:

125 towermen, 5 months, at average of $90 per month..................	$56,250
80 inspectors, 5 months, at average of $125 per month.................	50,000
500 fire bosses, 5 months, at average of $15 per month................	37,500
Maintenance of towers, telephones, tools; also annual telephone charges..	15,000
Harrisburg, office, district foresters' salaries and expenses..............	90,000
Publicity	25,000
Contingent, for extinction and other miscellaneous expenses............	30,000
	$303,750

This expense in the course of years will be reduced because of the fact that in certain localities hazards and risks will be removed and a part of the permanent organization and equipment may be discontinued. Especially is this the case within and near State forests, where it is reasonable to suppose that on account of intensity of actual forest work there will be men on guard constantly and paid regularly on constructive work, who in connection with that work will take care of any protective measures that may be necessary thus reducing expenditures for distinctly protective operations, at least as far as fire is concerned. Likewise, as soon as large tracts of forest area are placed under actual

forest management, as many areas now are in Pennsylvania, protection expenses, as such will decrease. In certain communities not only detection but also extinction forces may be dispensed with because of the local volunteers who will take care of their community interests, without cost either to forest owner or to the Commonwealth. However, it is not probable that the minimum expenditure can be reduced safely for the next ten years below $300,000.

The above figures refer only to the general State-wide protection organization without regard to ownership and do not include items of expense necessary for making the holdings of the State or private individuals accessible or for maintaining such roads and trails as are necessary to keep every acre of forest in a healthful and productive condition.

Another item of expense that must and will be gradually transferred from the Commonwealth is the cost of extinction. By all that is right the person responsible for the fire should bear it and fully 80 per cent of such cost will be placed where it belongs.

It is not expected that the goal set will be reached in one or two years, but it will be reached and it will be maintained at an expense that is extremely small compared with the value of the property protected and the total results which flow from forest protection.

Long before this goal is reached forest insurance will be good business and it in turn will help to maintain and increase continuous forest production.

THE SPECIAL PLANTING PROBLEMS IN PENNSYLVANIA

By Geo. S. Perry

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It is notable in comparing the natural second-growth forests of Pennsylvania with those of New England, that while coniferous species in the latter region have held their own relatively, as compared to representation in the original forests, in Pennsylvania they have been largely replaced by slow-growing hardwoods. Without inquiring or seeking the cause for this fact, let us instead consider whether it is a desirable condition and what course we should adopt toward the forests as we find them.

Shall we build our future forestry upon the oaks, beech, maples, and birches—developing these species somewhat as the hardwoods are managed in France—or shall we strive to increase the area of coniferous stands? The first course may seem indicated by a general survey of the forest regions of North America and a realization of the extent to which our best hardwood lands have been, or will be, cleared for agriculture. But substitution is replacing hardwoods in use to a much greater extent than it is coniferous woods. Development of tropical lands will help to satisfy our future hardwood needs. Farm woodlots will always be essentially broadleaf in structure and a steady source of supply. With one or two prominent exceptions, intensive forestry upon a rational basis, everywhere in the world, is built upon conifers. As compared to hardwoods, they are usually easier to grow in pure stands and make better volume increment on poor sites. Constant demand for construction material and multitudious requirements of our mills, shops and factories for softwoods mean heavy transportation charges on our supplies, if we are content to produce only hardwoods in quantity. With the passing of chestnut, largely used in rough construction where it occurred, the need for a substitute is already keenly felt in some localities; and this need only a conifer can hope to fill.

From the above resumé and the history of forestry in other lands, it is safe to assume that the proper and cumulative tendency of Pennsylvania forestry will be toward the replacement of coniferous stands upon medium and adverse sites, where slow-growing, unthrifty, broken

or fire-injured stands of oak or beech, birch and maple now hold possession. This then brings us face to face with the first and most important forest planting problem in our State: How shall we replace desirable rapid-growing conifers upon the extensive areas where hardwoods can never be expected to make satisfactory increment?

Some may object at this time to emphasis on this proposition. The millions of acres of "scrub oak," bracken fern, and fire cherry land may seem to demand our present attention; but let us analyze this assumption. Bracken areas and most of the "fire cherry-aspen type" can be successfully planted up at any time with species adapted to soil and light conditions. Little or no expensive assistance later will usually be required to get a satisfactory stand established, though it may show some admixture of locally occurring hardwoods. So these waste land types really present no special silvicultural problem. Funds for planting and protection are the *sine qua non.*

The "scrub oak" areas are a truly baffling problem for direct attack. Planting and studies in this type at Mont Alto and elsewhere have gone far enough to demonstrate the financial futility of expensive planting on such sites, followed by much more costly liberation and assistance work. Final success even then is questionable. Persistent and strenuous root competition combined with immediate over-topping by sprout growth will not usually permit the planted conifers to get ahead. While work along this line in the Mont Alto Forest has been complicated by deer-damage, yet results prove that this direct attack method is not the economical one for solution of the problem. A waiting game seems most promising. The history of areas once covered with scrub oak and now supporting fair stands of valuable hardwoods, considered together with studies and observation on large areas in central and southern Pennsylvania indicate that 95 per cent of our "scrub oak type" will develop a nearly complete crown canopy of the larger hardwood species, when completely protected for a decade or two. Even if this first crop is inferior and yields only cordwood, mine timber, and railroad ties; it seems economically preferable to the heavy financial loss that any other treatment may entail. Should a pure scrub oak area not come in to valuable species, yet after the lapse of 20 years without fire, the number of individual shoots per acre will be reduced to a minimum and their vitality sapped. Sweet fern, huckleberries, and other competing vegetation will be eliminated, so that root competition with planted conifers then will be much diminished on such areas.

The great problem of forest conversion may not demand immediate attention in every locality, but it is well to keep it in mind, and work on it may well be started where stands of blighted chestnut are being salvaged, or other areas ill-adapted to hardwoods are being cut over.

An area near the Forest Academy illustrates how conifers may be introduced upon hardwood lands, or how a change of species may be most cheaply attained. In 1909, a 50-year-old stand of shortleaf and pitch pine adjoining the forest nursery, was underplanted with Norway spruce—using small wood saplings—mostly oaks. These developed so much more rapidly than the spruce that for several years the planting seemed an utter failure. If left to nature, or had the stand been finally cut off in the usual way, the site would have certainly been occupied by the prevailing oak type of the locality. But in March, 1918, one end of this pine stand was wind-thrown. It was utilized during the succeeding summer, and the spruce were still so small that they received scant consideration from the loggers. Yet their recovery and recent growth has been little short of marvelous. They were aided by an assistance cutting in July, 1919, which removed inferior hardwood saplings, vines and shrubs. Measurements made in December, 1921, on both suppressed and liberated areas showed the appended results; and in passing it may be remarked that the difference would be even more striking but for the fact that the 1919 assistance work covered both areas:

	Average growth of trees on liberated area (feet).'	Average growth of trees under pine overstory (feet).
Total height	7.4	3.7
Current annual growth	1.56	.58
Mean annual growth	.57	.29

These results support the general theory in coniferous conversion planting; (1) either sturdy transplant stock must be used after cutting and removal of the hardwood overstory, or else (2) seedlings may be planted under the hardwood overstory a year or two before the stand is cut. In either case some assistance work may be advisable, but in the latter much less than in the former. The per cent of establishment runs much higher with the same grade of stock in underplanting than on cleared areas. This advantage is however largely nullified by mortality incidental to cutting the hardwoods, but there is a real gain in decreased nursery expense when seedlings instead of transplants are used.

There will undoubtedly arise a persistent and strong demand for transplants in our future planting work anyhow. This class of stock

was found to give much better results, where planting followed clearing, in replacing blighted chestnut on the Nolde Estate in Berks County, Pennsylvania. Even on the State forests, now the most favorable areas for planting have already been covered and reforestation of the remaining more adverse sites require use of transplant stock for good results.

Our second major planting problem looms large from the social and aesthetic as well as economic viewpoint. It lies largely in the mining and industrial regions of eastern and western Pennsylvania. It would be interesting to know the total area of land in our State occupied by quarries, culm-banks, dumps, and other deposits of raw or sterile mineral material. To a stranger passing through extensive localities, these absolutely desolate artificial mountains and ugly scars in the face of nature, are the most striking and depressing features of the landscape. We also often find in these same sections great tracts of denuded, fire-burnt, and barren surface soil. Such sites all present knotty problems in forest establishment—if not for us, at least for future generations—and the expense justified must not be limited by financial returns expected. Dividends in better citizenship and more attractive home-life and surroundings will help to pay the bill. This problem may be considered the exact antithesis of the first in one respect: where conifers are planted for conversion purposes, shade and competition by various woody and herbaceous plants may inhibit success but in this absence of other vegetation is the chief adverse condition.

Some planting has already been done upon such bare surface areas as here mentioned but results have not always been ideal or even satisfactory, and it may be objected to including culm-banks as a field for afforestation that (1) no trees at all can be made to grow on such a site and (2) many of these dumps are being worked over for low-grade coal and other products. To the first objection we can only reply that "America does not recognize the word *impossible*," and point out that England lends government sanction and funds toward the effort to get a tree growth established on mine-dumps. The work to date seems to result in fair success. ("Forests and Waters," Augustine Henry.) The working over of the material only delays the time when something should be done, and probably scatters it over wider areas.

To get results on these sites adverse to tree growth and devoid of nearly all vegetation, I want to suggest planting in very early spring before the soil dries out, and the use of large nursery stock of aggres-

sive, intolerant, pioneer species. We can cite in support of this advice the experience upon old mine dumps and ore-dams near Mont Alto. At Pond Bank, one site in particular had defied efforts to afforest it with honey locust, black locust and white pine. In early spring, 1919, some large stock of Scotch, pitch and Banks pine was planted on one end of the area. These species established almost perfectly and now look quite promising. In 1911 Scotch pine was set on a somewhat similar site nearby, and today that area shows a dense crown canopy with tree of 12 feet in average height. Jersey pine natural seed regeneration came in abundantly on this last area soon after it was planted, although it had never been able to survive the summer heat and winter frost-heaving during previous years.

Located at the base of Little Mountain along the road from Mont Alto to the Lincoln Way is a former barren area, partially covered with subsoil from ore-prospect holes, which was planted up in 1910 with Norway spruce, Scotch and white pine. Many of the spruce and white pine seedlings failed to establish themselves, but the area was re-enforced naturally by the seeding in of pitch, shortleaf and Jersey pines. For the past four years, classes in silviculture at the Forest Academy have made measurements for growth studies and comparisons of the species now present on the area. Results from year to year have not varied much except for the better standing of the Norway spruce. About 100 trees of each species were measured, being selected as nearly as possible under similar light conditions. Data appended is by class of 1922.

	Average total height of measured trees (feet).	Average 1921 current annual height growth (feet).
Norway spruce	8.8	1.88
Jersey pine	8.2	1.76
White pine	9.2	1.48
Shortleaf pine	8.9	1.45
Scotch pine	9.3	1.28
Pitch pine	8.6	1.05

Soil conditions are quite similar for all species, except that for spruce and white pine probably average better than for the others, and pitch is on the most adverse site quality; though differences are really slight.

These studies show that our native hard pines grow well on open adverse sites. Even the despised Jersey pine will apparently surpass the much vaunted Scotch pine in height increment during youth. The size and good form of Jersey pine is also illustrated by a tree near this

area, standing where the public road crosses the Cumberland Valley Railroad track. This tree is 60 feet in height and 22 inches in d.b.h. It is still growing and seeding vigorously although enjoying no special soil advantages.

The Table Mountain pine is another aggressive species that certainly possesses pioneer ability for use on sterile soils everywhere. While essentially a tree of the mountain summits, it occurs sparsely along the base of the South Mountains, where it shows such good form that for a long time it passed unnoticed among its pitch and short-leaf associates. Recently the Forest Academy class in dendrology found a tree within 100 yards of the Mont Alto Forest Nursery whose total height was 68 feet, with 35 feet of clear length, and with a d.b.h. of 21 inches.

Table Mountain and pitch pines have marked value from the standpoint of wild-life conservation. They not only bear seed at an early age and almost annually, but our seed collection work shows that less than 10 per cent of their cones open prior to January 1. Some of their cones remain closed until April or May but a preponderant part of their seed is released during the bitter cold, mid-winter days of high winds and intermittent sunshine. Not only do squirrels appreciate the unopened cones; but quail, grouse, and numerous smaller birds gather in the hospitable shelter of these pines when snow buries other food resources, and the loose wings scattered on its white surface speak eloquently of ravenous appetites satisfied with sustaining food.

The Japanese red pine, Austrian pine, Banks pine, lodgepole pine, and some other exotics to Pennsylvania promise good growth upon open areas of sterile or raw mineral soil. Experimental planting with such trees is highly desirable but our own modest and possibly equally well adapted hard pines should not be neglected in laying a foundation for the solution of this second planting problem.

NOTES ON THE FORESTS OF RUMANIA[1]

By John D. Guthrie

U. S. Forest Service, Portland, Oreg.

Rumania is conceded to be the same territory which once constituted the old Roman province of Dacia, subjugated by the Romans under Trajan early in the Christian era. Rumanians of the present day are said to be the direct descendants of the fusion resulting from the old Roman conquerors and colonists with the native population. Philologists claim that many Rumanian words of today keep unchanged the form used by Cicero and Virgil. After the Roman legions withdrew (A. D. 271) the country was overrun by Slav hordes and the natives were driven into the Carpathian Mountains where they remained until the end of the 13th century. About this time they left their mountain strongholds and established the principalities of Walachia and Moldavia. Their later history shows the country dominated for long periods by the Turks and the Greeks.

The Rumanians are a Latin people and not a Slav race, as one might suppose from their Slav and Magyar neighbors, their language superficially resembling a mixture of Italian, Spanish, and French, the French language being the official language and spoken quite generally throughout the kingdom.

Before the World War Rumania consisted of three provinces—Moldavia, Walachia, and Dobrudja—with an area of 53,489 square miles, or slightly greater than the area of England and Wales. The fortunes of war, and the Versailles Treaty, added to the kingdom three provinces, or 68,793 square miles, thus more than doubling its size; the new Rumania almost equals the combined area of England, Scotland, Wales, Ireland, and Belgium. It gained by the upheaval of 1914-18 the provinces of Transylvania from Hungary, Bukowina from Austria-Hungary (which province it had lost to Austria in 1775), and Bess-

[1] These notes are based largely on data secured and investigations made by the writer in Paris in 1919, while a member of the American Military Mission to Rumania working under the War Damages in Allied Countries Commission of the Peace Conference. The writer was the chief of the Section of Rural Activities (Forests and Agriculture) with the Rumanian Mission; this mission, however, never reached Rumania.

arabia from Russia. The Peace Treaty by adding land area naturally increased the population, from some eight million before the war to some seventeen million at present.

TOPOGRAPHY AND PHYSICAL FEATURES

The country is for the most part of rugged topography, with many large rivers and high mountains. The Transylvanian Alps form a sort of backbone through the central portion of the nation, with the drainage south and southeast on the southerly slopes, and west and northwest on the northerly slopes. Outside of Dobruja, the whole of Rumania is included in the north basin of the lower Danube. It is an inclined plane, roughly divided into three zones—steppe, forest, and alpine; the third or alpine is one of violently contorted strata, leaving many transverse valleys. The Dniester River forms its eastern or Russian frontier, and the mighty Danube most of its southern. Other important rivers are the Pruth, between Moldavia and Bessarabia in the eastern part of the country, the Maros in Transylvania, and the Sereth and Aluta in the southeast. The Transylvanian Alps, with a length of some 230 miles, are easily the dominating topographic feature of the country, with bold, rugged crests. Prior to 1914, Transylvania contained many large landed estates or hunting forests, the pleasure resorts of Hungarian nobility. More than twenty bathing places with medicinal springs had been known and used for hundreds of years. The Transylvanian Alps are the highest and wildest mountains of the entire Carpathian system, the mountains rising to heights from 2,000 to over 8,000 feet. Through these mountains are many mountain passes, famous in Balkan history—Vulcan, Red Tower, Gyimes, and the Iron Gate. Negoi Peak in central Rumania reaches an elevation of approximately 8,345 feet, while Parangu Peak is slightly under 8,000, and Lakocz Peak is 6,000 feet. The province of Dobruja is a low, flat plain bordering the Black Sea, Bessarabia is relatively low and largely an agricultural and pasture country; these have little of interest to the forester. It will be remembered however that it was through Dobruja that Mackensen began the real attack on Rumania for the Central Powers in September, 1916. Much of Walachia is unimportant from a forest standpoint, as well as parts of Moldavia, though extremely important as an oil-producing region.

THE FOREST REGION

The Transylvanian Alps are wooded to a height of over 5,000 feet. The lower slopes have beech (*Fagus sylvatica*) as the typical tree, though at lower elevations on the Moldavian Plateau and in the Walachian Plains, as well as on the hills of Dobrudja, there are extensive stands of oak. Higher in the mountains are conifers, Norway spruce (*Picea excelsa*), silver fir (*Abies pectinata*), Scots and Austrian pine (*P. laricio* and *sylvestris*) and larch (*L. europea*). There are also oak (*Q. pedunculata* and *sessiliflora*), and the European species of elm, maple, walnut, and poplar. For the Transylvanian region hardwoods predominate—84 per cent hardwoods to 16 per cent softwoods. In 1914 the oak type was estimated to cover 715,000 acres, beech-oak at 700,000 acres, beech at 550,000, and spruce, pine, and fir stands at 312,000 acres.

For the area of old Rumania (53,489 square miles) forests covered approximately 20 per cent of the entire surface. With its present boundaries this percentage is probably increased to approximately 40 per cent. The Transylvania plain is the most important from a forest standpoint, and is 37 per cent forested.

The forests of Rumania were for many generations either long neglected or exploited in the most reckless fashion. In 1914, within the boundaries of old Rumania, there were estimated to be 5,705,750 acres in forests, the best stands to be found in the mountain region of northwestern Moldavia. According to Pittard,[2] the districts of Gorj and Valcea, both in the Department of Altenia, Walachia, have the most extensive forests in the kingdom, the first containing more than 460,000 acres. The four Moldavian districts of Suceava, Neanitzu, Bacan, and Putna, all bordering on the Transylvanian mountains, contain 1,418,000 acres of forest. Nine districts alone, out of the thirty-two that made up old Rumania, showed a wooded area more than half of the forested area of the entire kingdom, or 5,600,000 acres.

At elevations of about 7,000 feet the forests cease and one enters the Alpine region, steep, grass-covered slopes, the region of summer pasture lands for sheep. Here six million sheep find summer range, coming each spring from the vast alluvial plains to the south and la Balta—the marshy plains of the lower Danube—and by slow stages finally reach the Alpine pastures which they leave in the fall to return to the low country, much as sheep are handled in our own Western States.

[2] La Roumanie—Eugene Pittard, Editions Bossard, Paris, 1917.

PAST EXPLOITATION

Prior to 1885, when the Forest Code was promulgated, the exploitation of the forests by the private owner was practically unimpeded; no restriction was laid against their commercial destruction. Pittard says: "The losses were still further increased by travelers through the country. In the openings sheep men made their fires at the base of the most beautiful beeches, cattle and goats without regard grazed among the young growth. Each one cut the tree it best suited him to fell."

Prior to the war the lumber industry was controlled by several powerful stock companies, largely of Austrian, Hungarian, and German origin. In 1913, fourteen of these organizations represented a stock capital of $13,140,000. The net profits of these concerns varied from 1 to 33 per cent. There were a few peasant organizations with small capital and small output. Lack of wagon roads and railroads [3] made access to large timber areas difficult. Prior to 1914, there were 71 sawmills employing over 12,000 men, with 50,000 men employed in the woods end. One of the oldest lumber concerns (headquarters in Geneva, Switzerland), established in 1883, with a capital stock of three and a half million dollars, employed 1,000 men and had an annual production of some 70 million board feet. There were large furniture factories at Jassy and Bucharest. The paper and cellulose industries were important, ten plants being engaged, with an output in 1910 valued at $1,900,000. One paper plant at Busteni, turning out paper of all kinds, had an annual output valued at $600,000, and had 600 workers.

With a rough, broken forested country and with many large streams, it is but natural that the streams should be driven. Pittard thus picturesquely describes the launching of a log raft:

"In a broad, laughing valley with open slopes the village with its wooden houses is set. On the banks of the river, which serves as the frontier for several miles, the felled firs by hundreds and by thousands are lined out. Some twenty boles, their tops forward, are solidly held in place by a crossbar and form the first raft. They join then several of these by a flexible switch of supple bark, and the long train of wood, having at each end a rudder, which is simply an oar, is launched out into the stream."

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[3] In 1917 the mileage of wagon roads was placed at 2,382 and railroads at 26,385.

OWNERSHIP

The largest owner of forest lands was not, as one would naturally suppose, the Government. Private owners are said to have held a forest wealth of 3 million acres or 54 per cent of the total area before the war, the remainder divided between the Government, Crown lands, and communal and public institutions. Bungeleann [4] says that in 1912 only 8 per cent of the forest area was being exploited commercially but that timber exports increased in the ten years prior to 1912 from $2,900,000 to $4,700,000. He gives the proportion of forest ownership as 3 per cent Crown forests, 43 per cent in State and communal forests, and 54 per cent privately owned.

ORGANIZATION

Rumanian forest administration and policy since 1885 have been patterned largely after French models. This was due largely to traditional close relationships and racial ties with France. Thus in 1885 three French foresters were called to organize a State forest department and to start the preparation of working plans. As a result of the new organization, by 1894 the income from the State forests had doubled. By 1889 a forestry association had been formed, with an official journal. The real awakening in forestry in Rumania thus was almost simultaneous with the beginnings of forestry in America.

Rumanian foresters were formerly educated in France, at Nancy, until the establishment of courses in forestry at the Agricultural Institute at Bucharest in 1892, and a forest school at Branesci (near Bucharest). In this connection it is interesting to note that wood carving is taught in many of the schools.

The national forest organization had developed to such an extent that by 1898 there was a forest director, with 156 foresters (trained largely at the national forest school at Branesci), and over 2,500 under-foresters or rangers and guards. A total of 18,000 acres of sand dunes had been planted as well as some 9,000 acres of plains country, from some 330 acres in forest nurseries.

Prior to the war the State was cutting about 22,000 acres annually, yielding about 1 million dollars return, the administration was costing (1903) about $240,000, or a net yield of 30 cents per acre. Private forestry was much less developed, although there were large acreages owned by royal personages and Austrian companies and associations.

[4] Les Bois et Fôrets en Roumanie. C. C. Bungelcann, Paris, 1912.

REGULATION

Before the war Rumania was an important wood producing country; it not only supplied practically all of its own needs but exported annually 613 million board feet of hewn and sawn timber and lumber. Most of this went to Turkey and Mediterranean countries. Private forests were being rapidly depleted, only State and forests of large proprietors being in fairly good condition, much as the situation is today in the United States.

As early as 1847, the National Assembly had made attempts to regulate the cut and to bring about some sort of control over the rights of the user, but with little real effect. In 1863 all cloister property was secularized and taken over by the State. It was not until 1881 that the first comprehensive forest law was passed; this was followed by several acts up to 1885, thus starting a real protective policy. The forest code recognized State, Royal, and Communal property as of public concern, and brought private forests under the supervision of the State where such forests were located on steep slopes, near watercourses or near frontiers. The forests thus designated as protective comprised about 84 per cent of the entire forest area of the kingdom.

RUMANIA IN THE WAR

Rumania declared war on August 27, 1916, and, against the advice of the Allies, threw a large force into Transylvania. A large part of the population of Transylvania being of Rumanian stock this campaign was eminently successful. However, in September, 1916, Mackensen invaded Rumania through Dobrudja, capturing Constanza, the principal Black Sea port, on September 22, 1916. Falkenhayn entered from the west, inflicting a severe defeat on the Rumanian army on September 26 at Red Tower Pass. Later the two armies joined and on December 6 took Bucharest, the capital (known as "The Little Paris of the East"), the Rumania government moving to Jassy. The Central Powers remained in control of Rumania throughout 1917. Russia's *debacle* in 1917 sealed Rumania's fate, forcing her to agree to suspend hostilities in December, 1917, with the positive statement that she would not enter into peace negotiations. However, she was forced to do this, after Germany had arranged peace with the Ukraine in February, and Rumania signed peace terms at Bucharest in May, 1918. With the Central Powers in control of both of the important Black Sea ports, Constanza

and Odessa, and also a large majority of the kingdom, Rumania was strictly *hors de combat* for the remainder of the war.

Two years' occupation by the Central Powers drained the country of foodstuffs, clothing, shoes, and practically all manufactured goods, and left destroyed the greater part of the oil refineries.

EFFECT OF THE WORLD WAR ON RUMANIAN FORESTS

Rumanian forests in northern Moldavia and portions of Walachia were apparently recklessly exploited [5] by the Central Powers during their occupation of Rumania, more especially in connection with the taking over and very extensive use (and later destruction) of the oil refineries in the districts of Prahava, Dambovita, and Buzan in Walachia and Bacan in Moldavia. This region at the beginning of the World War was recognized as one of the important oil fields of the world, furnishing 4 per cent of the world's supply at that time.

As a result of the Versailles Treaty, Rumania now occupies a very important place from a European forest point of view. By the treaty she now owns the immense timber resources of Transylvania, formerly belonging to Hungary, also those of eastern Hungary proper, as well as Bukowina, formerly Austrian territory. The timber production of these areas added to Rumania is ten times greater than was that of old Rumania. Prior to 1914 the forests in the added portions were largely owned by Austrian and Hungarian subjects and held either in large estates, or by limited societies, directed from headquarters in Vienna or Budapest. Exploitation of the forest resources in old Rumania proper was centered and run largely by Austrian and Hungarian concerns.

When the Rumanian government took possession of its new territory one of its first acts was to nationalize all industries and to force all industrial headquarters to be moved into Rumania. To complete Rumanian control acts were passed providing that Rumanian subjects must constitute the majority in all industrial managements and that the majorities of shares in organizations and limited societies must be sold to Rumanian banks and financiers. Naturally this has brought about radical changes in the management of the timber business in the country. Universal suffrage was effective January 1, 1919, also a division of large landed estates was effected whereby no single proprietor was allowed to own more than 1,250 acres.

[5] It was to assess this damage that the writer was assigned to the American Military Mission to Rumania in January, 1919.

In spite of these revolutionary changes in timber management and ownership, reliable reports would indicate that the principal lumbering operations were functioning throughout 1919. Mills were running continuously and large stocks accumulated, but by 1920 prices fell and there were no markets, due to a collapse in the transportation systems not only in Rumania but throughout the Balkan States. Even before the war Rumania suffered from a shortage of locomotives [6] and railroad cars and since 1919 this shortage has been intensified. Now it appears that there are hardly enough cars for the transportation of food supplies, much less for forest products. In spite of this depression, mills have continued to run, with consequent enormous increases of stock.

With enormous stocks on hand, prices below the cost of production, and the general industrial depression of the country, are factors which are apt to mean a serious set-back to the cause of Rumanian forestry.

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[6] An official French report of January, 1919, stated that Rumania had plenty of cars but no locomotives; that prior to 1914 there were 1,100 engines in the country, but by 1919 there were only 100.

A WORD FOR THE LOWLY PINON

By Walter J. Perry

Lumberman, Carson National Forest

The pinon tree (*Pinus edulis*) of our Southwestern country is classed as an "inferior species." It is, if one has in mind only the production of "clear" or "select" lumber, or for that matter any kind of lumber. However, while it falls short as a lumber producer, it is not by any means valueless. In fact it has a very considerable value in more than one way even before an axe is put into it, though when converted to railroad ties it gives equal service with Douglas fir and sells at the same price.

Heretofore, apparently because, or on the assumption that it was an inferior species pinon has been cut rather promiscuously and it seems clear without due regard to its real value in the general scheme of things.

We all know what is meant by the old saying that "a half loaf is better than no bread." All right. Along the lower limits of our western yellow pine stands the delicate balance of temperature, air and soil moisture, etc., is such that below this line the yellow pine can not successfully reproduce itself, but the conditions are just right for the pinon which in its turn, and for the same reasons, can not encroach on the yellow pine. There is ample evidence that this line has not remained stationary, but the change has been very slow and the reasons therefor would seem a more proper study for a geologist than a forester, for while the forester may think in terms of centuries perhaps—and none too long a period—he does not customarily bother himself with geologic ages. The important fact for the forester is that this line *is* established beyond his control, and he must keep this fact in mind in handling his forest.

In harvesting a crop of pine timber along the lower limits if we came upon a few pinon in mixture they would be unhesitatingly cut out, with the expectation of replacing them with the more valuable yellow pine. This would be good forestry. But when we get down well below the type line we find we have only our "half loaf." Shall we throw this away merely because it is not a whole loaf? Not yet! We

must still practice "good forestry" with the material given us. At least let us first examine whether this "half loaf" is not of considerably more importance than we may have at first thought.

To begin with, we can not produce openings by cuttings in the pinon type with hopes of restocking them with anything better. We can not produce very extensive openings with hopes of restocking them with *anything* within a reasonable time. The reason in the latter case lies in the fact that the pinon is of low stature and the wingless seeds are large and heavy, and are not therefore cast a sufficient distance from the parent tree to reseed any considerable opening. In fact the seed are all dropped beneath the crown of the tree, and except for those resulting from seed carried accidentally or by birds or rodents, practically all seedlings spring up under or in the immediate vicinity of the parent tree, though on steep slopes they may, of course, seed some distance by rolling or washing.

Pinon in the seedling stage is not only tolerant of shade but appears to require it, although later it must have full light. Therefore practically all seedlings start their growth under shade, and for the same reasons all mature stands are very open. Reproduction is almost invariably quite scanty.

The pinon pine is of extremely slow growth, and while it may occasionally bear some seed when only 6 to 8 feet high, or 30 to 40 years of age, it does not reach full development until well over 100 years of age.

From the above it appears clear that in cutting pinon it is necessary, in order to perpetuate the stand, to carefully avoid producing any considerable openings, especially in the absence of abundant reproduction. This can not be done under a "cut and slash" policy. In order to take care of the silvical interests of the stand it is just as essential that individual trees be designated for cutting as it is that sawtimber of other species be so designated, and this should be done by a forester competent to judge what methods will best serve those interests.

The pinon is valuable in four ways, either one of which justifies its existence. Let us take them up, not necessarily in their dollars and cents order, and try to determine the greatest value.

(1) *Watershed Protection.*—The natural and usual habitat of the tree is dry mesas and dry rocky and gravelly south and west slopes. On such locations other ground cover is usually very scanty or almost entirely lacking. On steep slopes these hardy trees manage to exist and hold—barely hold—the soil against serious erosion. No other

species, with the possible exception of the still less valuable scrub juniper, would have a chance to exist under the same conditions. The pinon is now holding erosion in check and helping to regulate the waterflow from many thousands of acres which, if the species were suddenly wiped out, would soon be eroded down to the bone, and the resulting debris carried by the mountain torrents and spread across the valleys. Perhaps this value can not well be expressed in dollars and cents.

(2) *Fuel.*—The pinon, after its usefulness for other purposes is past, produces an excellent fuelwood, surpassing all the conifers of the Rocky Mountains in this respect. Moreover, owing to its lower altitudinal range, it is more accessible for this use than the other species.

(3) *Merchantable Timber.*—Much of the greater part of pinon which is cut for commercial purposes is converted into railroad ties. For this purpose it is rated equally with the Douglas fir and much above all the other conifers. However, owing to its very open growth habits, its extremely slow growth, and the fact that it is quite rare for a tree to produce more than a single tie, its per acre value for this purpose is but small.

Assuming that it is cut for ties—and only the best trees will answer the purpose—and that a stumpage price of $3 per thousand feet, or say 11 cents per tie is obtained, and assuming also that an acre is fully stocked with mature timber, or with timber of suitable size for ties, then it would produce at the outside twenty-five to thirty ties, or say $3 per acre—and when would it yield its next crop?

(4) *Pinon Nuts.*—The tree has one value not possessed by any of the other conifers; it produces an edible and increasingly popular nut. While some fruit is borne every year by trees here and there, large general crops are produced only at intervals of from two to seven years. It appears that the largest crops are produced in a year following one of unusual precipitation. It is not to be supposed that only the pinon jays and the rodents receive the benefits of these crops. By no means. When such crops occur, as happened in 1921, the population takes full advantage of the opportunity and the nuts are harvested in almost unbelievable quantities. The harvest commences just as soon as the cones are opened by the first frosts and continues right on through the winter, as the snows lay but a short time on the sunny slopes. The nuts thus exposed to the weather do not deteriorate though, of course, many are consumed by the birds and rodents, such as mice and mountain rats. The harvesting consists simply in picking

the nuts off the ground by hand one at a time after sufficient have fallen to render it worth while. The cones open very gradually, and no amount of shaking will serve to dislodge the seed from the apparently open cone scales until they are good and ready to fall. The gatherers sometimes take advantage of the hoarding instinct of Paddy Pack Rat and on ferreting out his cache are rewarded at times by as much as four "almudes" of nuts. These are invariably fine and sound, as Paddy stores away no poor ones.

Following are some rather interesting figures based on personal observation supplemented by extensive inquiries among natives and others engaged in the pinon nut industry—for so it must be classed.

It is conservatively estimated that in 1921 the harvested and sold crop of pinon nuts amounted, in the State of New Mexico alone, to 1,176,000 pounds. The retail value of this crop, which sold at about 20 cents per pound, was only slightly less than a quarter-million dollars.

The prices paid the gatherers by local merchants and shippers acting as middle men, ranged from 7 to 13 cents per pound. Probably the average was around 9 cents per pound.

The nuts are usually sold to local dealers by the "almud" (an old Spanish measure of 400 cubic inches) which, of pinon nuts "colmado" or heaped up, weighs 11 pounds. Two of these measures, or 22 pounds, is considered a fair day's gathering, though some especially dexterous persons can pick up 40 pounds. Principally, women, children, and the old men engage in the industry. In addition to those sold, large quantities of the toothsome nuts are consumed locally and currently as well as stored away by the settlers, both Mexican and American. As an instance of what this forest product may mean to some in the way of a livelihood it is mentioned that one aged man and his equally aged wife gathered and sold $190 worth of the nuts in the fall of 1921. From the little Mexican Plaza of Vallecitos, N. Mex., alone there was shipped during the fall and early winter some 80,000 pounds of the nuts. It is understood that the pinon nut it now being exported to Europe. It is certain that the domestic demand for them is increasing yearly.

In a good crop year a good thrifty tree, such as would be suitable for a railroad tie, may produce 20 to 30 pounds of nuts. At 9 cents per pound these are worth, say, $2. But the tree bears, let us assume, only each seventh year. Then the average annual value of the crop is 28½ cents. If the tree is cut for a tie it brings 11 cents, but imme-

diately ceases to bear pinon nuts, though it may, of course, be replaced by another tree in a century or so.

The U. S. Forest Service ideal is the sustained "greatest good to the greatest number." Let us take a look at the matter from this angle, and consider first the cutting of the timber for ties. The benefits to be derived by the people consist of the stumpage paid and the employment furnished by the cutting and hauling of the ties. The average tie hacker makes about ten pinon ties per day, and earns thereby 25 cents per tie, or $2.50. The tie hauler delivers twenty ties and earns 25 cents per tie, or $5. The contractors spends his time on the operation and gets 7 cents per tie. Figured on a single tree or single tie basis, there is furnished slightly over 1½ man-hours of employment, with a gain in wages or in profits of 68 cents and to this is added 11 cents stumpage, making a total of 79 cents—but the tree is gone! The value of the tree top for cordwood is almost negligible owing to the fact that much of it is inaccessible for hauling or is at such distance as to render handling it quite unprofitable, and the added fact that when felled as a green tree it very soon decays, although if allowed to stand to maturity, and die standing, it may remain sound for a great many years.

We have assumed an annual nut production of an average value of 28 cents or, we will say, 3¼ pounds of nuts. The harvesting of this crop would furnish employment then for 1½ man-hours annually, with a gain in wages of 28 cents, and by the time it has produced its third crop it will have more than produced its "cutting value" in nuts alone —and the tree is still left with its full ultimate fuel value and its no less real though less tangible value as a watershed protection and temperer of the climate.

As alluded to above, the pinon crop is gathered, mainly by the women, children, and old men. It thus furnishes employment to those unsuited to heavy labor and enables them to help out a scanty farm crop or a low wage of the head of the family, and frequently represents the difference between a mere existence and comparative wealth and comfort.

"The greatest good to the greatest number" is a mighty fine ideal; the highest possible ideal. Let us keep our eye on the bird. Pursuant to this ideal the Government has set aside and protects certain parts of our forests as recreational areas for the people, and with little thought of actual dollars and cents returns. This is right and proper. The forest belongs to the people, and the people are paying men to take

care of it for them. In these cases "the greatest good to the greatest number" is obtained in this manner. The same lofty ideal should guide no matter whether the forest under management is the lowly pinon grimly holding the front lines against the desert, and incidentally contributing directly and quite materially to the support of a population in a none too hospitable land, or of cloud-scraping Sequoias towering over the Pacific coast and furnishing pleasure and inspiration to those so fortunate as to be able to visit them.

Yes, the ideal could hardly be improved upon. The practice of it is what the people are paying for.

Question.—Is the pinon tree with its annual food crop value of 28 cents plus its value as watershed protection, plus what we might call its residual value as fuel, worth more to the people standing or down? The writer has not the slightest hesitation in answering "standing," nor in recommending that cutting in this type be confined strictly to "improvement cutting," that is, removing only dead, overmature, diseased, etc., trees, the trees to be removed being marked or designated by a competent forester. That, and nothing less, it appears to the writer, would be "good forestry."

STORM DAMAGE TO MICHIGAN FORESTS

By P. L. Buttrick,

Assistant Professor of Forestry, Michigan Agricultural College

Michigan has recently been visited by an ice storm of unparalleled severity, a storm which broke down and completely wrecked trees, pole lines, and transmission systems and which paralyzed all rail communications. In the cities and towns it put the electric light, telephone, fire alarm, and traction systems out of service. It became necessary to suspend school sessions, shut down factories and close offices. Streets and sidewalks became impassable because of the masses of broken poles, wires, and tree limbs brought down by the enormous weight of ice. In the woods logging ceased, as neither men nor teams could work safely among the falling trees and branches.

The greatest damage was, of course, to wires and trees. Pole lines throughout the region will have to be practically rebuilt. Hardly an uninjured tree remains in the whole storm zone. Some of the towns look from a distance as though they had been under heavy shell fire, so badly are their street trees riddled and broken. In the woods the damage is on the scale of that caused by great forest fires and tornadoes. It will require 25 years at least for the trees and forests of the stricken area completely to recover.

Early in the evening of February 21, 1922, it began to rain over most of the lower peninsula of Michigan. The temperature was close to the freezing point, consequently the water froze as it fell and soon everything was a glare of ice. In the southern portion of the State the storm did not continue long. It cleared up the following day and the ice melted before any damage was done. In the extreme northern portion of the region the storm started as a snow storm or speedily developed into one. This snow storm lasted for nearly three days and proved to be one of the severest in years, but did little damage other than paralyzing all communications for over a week.

Between these two zones it rained for more than two days, the total precipitation varying from 1 to 1½ inches. The latter figure being more than the average precipitation for the entire month. The temperature remained during the entire storm at a point slightly below freezing, consequently everything became covered with a dense mass of ice.

The ice on tree twigs became by measure in the worst portion of the storm zone from 5 to 6 inches thick. Throughout the region it averaged about 2½ inches. Ordinary stock woven wire fence became covered with a solid sheet of ice several inches thick.

After the storm the weather remained cold and the ice did not begin to melt for nearly a week. During this period a gale was greatly feared, as it would have greatly increased the storm damage, but fortunately it remained relatively calm as it had during the storm itself.

The ice zone was from 80 to 100 miles wide north and south and extended in a zone clear across the State from Saginaw Bay to Lake Michigan. It reached Lake Michigan in destructive force only at Frankfort but became devastating a few miles inland. North of Traverse City on the western part of the State and Alpena on the eastern snow took the place of ice. The southern limit of damage corresponded about to the southern limit of the old pine region.

The region about the city of Cadillac, in Wexford County, seems to have been the center of destruction. While the region about the city of Grayling, in Crawford County, a little to the northeast, owing probably to its higher altitude was visited only by snow and largely escaped damage. The ice zone covered all or parts of 28 counties, or an area of approximately 14,000 square miles, this being a trifle less than one-fourth the area of the entire State. A second and much less severe storm extended the damage slightly to the north, and a few weeks later, the last of March, a third visited the southern part of the State. Neither of these storms can be compared to the first in magnitude of damage.

Formerly the region of the big storm was an important center of the white pine industry. Today practically all the pine is gone, but there remains a certain amount of mature hardwood timber, and a not inconsiderable amount of cedar in the swamps. Nearly every farm has a woodlot, so that the forest is still quite important in the life of the community. In the western portion of the region there are many orchards. The cities and towns are reasonably numerous and most of them are well supplied with shade trees.

Hardly had the storm ceased before requests for aid began to be received at the Forestry Department of the Michigan Agricultural College from towns in the stricken zone who feared that they were doomed to lose all their trees. So the writer was sent out to visit the region and advise with them as to what could be done. Then followed a trip which in many ways strongly resembled travels in the war zone shortly

after the armistice, so badly was the general life of the communities disorganized. In cities and towns it was advised that they secure the services of an expert to take charge of the tree repair work necessitated by the storm. In the country damage cuttings were recommended to salvage the destroyed trees.

Some account of the form of damage may be of interest to readers of the Journal. The damage to tree growth was mostly in the form of broken tops and branches, not only did street, shade and orchard trees suffer such loss but forest trees were often broken off and were generally stripped of all branches.

Owing to the fact that there was very little wind in connection with the storm and that the ground was frozen few trees were uprooted. Had the wind blown strongly even with the ground frozen the majority of the trees would have been snapped off short somewhere in the trunk. Had the ground been unfrozen and a wind blown in addition a large part of them would have been overthrown.

It is too early to estimate the entire damage. What proportion of the smaller trees will straighten up and continue to grow and whether the larger ones will be able to survive the stripping off of their branches are things which we must wait to know.

It is certain that there will be a great deal of secondary damage due to the action of fungus, insects, and fire. The wounds caused by breakage will offer convenient points of lodgement for fungus spores which will start decay and perhaps eventually destroy the tree. Likewise a large infestation of insects may be expected. Owing to the large amount of debris on the ground in the form of fallen trees and branches, the danger from fire when this material dries out will be very great.

In young woods the enormous weight of ice bent trees less than 8 inches in diameter double so that their tops lay on the ground. Many of them snapped at the point of greatest strain, others simply cracked, still others were apparently uninjured but may not be able to straighten up after having been bent over so long.

Trees in woods where the stand averaged 8 to 12 inches in diameter lost practically all their branches and remain standing as bare poles or were broken off a short distance below the crown. In the big timber the smaller branches were sheared off so completely that the trees remain standing as gaunt skeletons. The litter of fallen branches on the ground is so great that it is difficult to walk through it. It resembles logging slash.

Open woods suffered more than dense ones since the trees were not able to give each other mutual support. Middle-aged stands suffered the worse mechanical damage, many of them may possibly be entirely ruined.

The damage to individual trees standing in the open was in proportion to their height and the extent of their crowns. Tall and wide-crowned trees suffered most severely. Low-crowned trees with few large limbs, least. Among orchard trees this was particularly noticeable. The low compact-crowned trees of the younger orchards were far less damaged than the larger higher-crowned trees of the older ones. Many of the latter were absolutely ruined. Among trees of the same size and development damage was greatest in the soft and brittle-wooded species. The aspens and poplars, for instance, suffered much more severely than oaks and ashes.

About all that can be done to repair the damage to the forests is to make damage cuttings, removing all the trees that are evidently too badly broken to have a chance of recovery, and to clean up for cord wood as much of the litter of broken branches as possible to decrease the fire risk.

It will probably happen that all the trees that die will not succumb at once. The owner will perhaps have every year, for several years to come, to remove the trees that gradually weaken and die.

Shade trees suffered in proportion to their size, location, and kind. Small ones in protected locations escaped with only a few broken branches, middle-aged ones generally had their lower branches bent completely down to the ground and often cracked but seldom broken off. The upper branches were broken or twisted off and often the crowns were entirely broken out. Large trees generally had their branches entirely shorn off. Trees with decay in their trunks or larger branches were generally completely broken apart and ruined.

Although scarcely a shade tree in any of the cities and towns of the storm zone escaped severe or at least considerable injury not more than 10 or 15 per cent appear to be damaged beyond recovery, these being those which because of decay were too badly broken to be worth saving. The remaining 85 to 90 per cent will probably survive, but if not given expert care will survive only as caricatures of their former selves and will gradually go to pieces under the influence of decay entering through the broken branches. The reasons such a comparatively few trees were immediately completely destroyed are: first, their compara-

tive small size—a few large shade trees are found in these towns—and second, the absence of wind.

The behavior of different species of trees under the effect of the ice was quite interesting. The most striking thing about it was the relative immunity to damage shown by the evergreens. Evergreen trees of all sizes stood up remarkably well. They became coated with a layer of ice over the entire outside of the tree but the interior escaped so that the total weight upon them was less than in the case of the hardwoods where every individual twig was coated. Had there been a heavy wind in connection the story would have been quite different. In that case evergreens would have suffered the most severely. In the woods the evergreens suffered most in the class of trees from 6 to 10 inches in diameter. These were occasionally broken off somewhere midway in their height. Smaller ones were bent over but will probably straighten up in time. Larger ones frequently had the extreme tip broken out. Very large evergreens suffered scarcely at all. In the open evergreens of all sizes, since their crowns extended rather close to the ground or were small and open, escaped practically uninjured. There seemed no special difference in the degree of injury to evergreens of different species.

As between different species of deciduous trees, injury seemed to be in relation to the brittleness of the wood and the form of the tree. Species with wide-spreading branches and soft brittle wood suffered most severely. Among shade trees the Carolina poplar answered these requirements and of all trees in the storm zone suffered the most. Practically all of them lost most of their limbs. In many places they were stripped down to bare poles. They stand today gaunt wrecks scarcely to be called trees. In the woods a close relative of the Carolina poplars, the trembling aspen, was almost as badly broken, only its general low height saved it from complete destruction. The Lombardy poplar on the other hand was very little injured. White birch, a tree which in its youth has a form somewhat like the Lombardy, was perhaps more apt to be broken off in its trunk than any other tree. Soft and hard maples behaved somewhat differently. In the case of soft maples breakage was mostly among the smaller limbs. In the sugar maple the upper limbs coming out from the trunk at a sharp angle were frequently wrenched out or broken off at the socket so that many of the trees of this species are complete wrecks and can be saved only by complete dehorning. The elms generally had their top and side branches completely sheared off so that little but the stubs are left.

Although often appearing in worse shape than the maples they stand better chances of recovering a satisfactory form. Oaks are not numerous in the storm zone except rather small ones on the old pine stump lands, these oaks mostly keep their leaves over winter, consequently they behaved much like the evergreens and were not greatly harmed. Larger red oaks which lose their leaves suffered about as did the maples. Of the less important trees ash and beech stood up well, basswood rather badly.

It will be exceedingly interesting to follow closely the processes of nature in repairing the unparalleled damage done in this section. We have little to go by in estimating the ultimate damage to the forest by such storms, and this one will give us valuable data.

A MINNESOTA FOREST PROBLEM—TO KEEP PINE LANDS PRODUCTIVE

By George C. Morbeck

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Lumbering in northern Minnesota is a most important industry. To maintain this industry is essential to the continued prosperity of the region. The bulk of the timbered and logged-off land is suited only to tree growth, and measures should be taken to make these lands continuously productive of wood. Unfortunately the forest conservation movement made but little progress in the years gone by in Minnesota, but in this respect she is no worse off than other states similarly situated. Of late, however, through the enactment of appropriate legislation headway is being made, and the state is rapidly forging to the very front rank in forestry work.

The cutting of the bulk of the pine timber in Minnesota was accomplished in a relatively short period. Numerous large mills operated by a variety of interests took their toll of stumpage, were dismantled and junked, or moved to distant but more fruitful fields. The operations were accompanied by almost complete forest destruction and desolation resulting in vast areas of barren "cut-over," non-productive, idle lands of no value, except potentially for the growing of future crops similar to those which had been removed.

The extent and the condition of the pine cut-overs are not fully realized by the casual observer. The nature of the country necessitates a rather intensive survey to determine even the approximate amount and the present status of these logged off lands. In many regions as far as one can see is a desolation of cut-over lands, difficult of description. The "cut-overs" are the result of destructive lumbering of a variety common to all the Lake States. The policy of the operators in regard to cutting seems to be to skin the land of every merchantable log or other forest product, since they do not intend to return to areas once logged, for future cuts. The feasibility of leaving the smaller trees upon the ground for cutting at some later time has probably never been seriously considered. Neither have owners considered it profitable to allow young virgin stands to remain intact until

they shall have attained greater volume, and hence greater value. The fact that thousands of acres of land are yielding logs averaging twenty-five to forty per thousand feet; and costing $22 per thousand to log and deliver to the railroad, should set owners to wondering whether small trees would not yield a greater return if allowed to stand until they had reached a larger size.

Mr. Sherman, in a recent address made mention of a tract of virgin old growth pine timber in Pennsylvania which is valued at $5,000 per acre. There are several tracts of young pine in New England which have actually sold at prices ranging from $500 to $1,500 per acre. Immature stands of pine are probably yielding a rate of interest on money invested, through volume, quality, and price increment as great as that which can be realized on money employed in other safe and legitimate investments. Logs running forty per thousand and costing $22 to deliver at the railside are produced at a loss. The logic employed in logging small timber is that the operating costs shall, in some measure, be borne by the more cheaply logged, larger, and more valuable timber, thus while reducing the profits on one class, the cost of production of another class is lowered, enabling it to be logged without loss.

Economically this reasoning is not as sound as it should be. The lumberman does not reason along similar lines in any other branch of the industry. There are, however, so many factors entering into this matter, that it will probably remain an open question to be settled for each individual project.

When a pine forest has been logged, it is usually burned over within a very short time either intentionally or otherwise. The first burning destroys the slash, down timber, accumulated debris, and all young growth. Subsequent fires consume the humus and other materials which have gathered since the last fire. The herbaceus plants now give way to shrubs such as sweet fern, hazel, dwarf maple, and to birch and aspen. The original forest has lost its identity and if nature is not aided in her work of restocking the area a century may elapse before another pine forest covers the ground. The "cut-overs" are often very picturesque. The rolling topography studded with great white boulders, and the rough slopes covered with glistening outcrops is a common sight. Blackened snags of pine and the white shafts of fire killed birch bear mute testimony of the forests there once were.

But it is not of these that we should concern ourselves particularly at this moment. Logged-off lands are a ghastly fact. The injury to the forest as a producer of wood cannot be easily remedied. Measures

to restore cut-over lands to productive forests should be undertaken, but above all things else, measures should be taken to prevent the formation of additional "cut-overs" of the type now existing. Elimination of the chief contributing factors—destructive lumbering and forest fires—are essential to the new order. Of the two evils fire is probably the greatest. A northern pine forest may be slashed under certain conditions, and yet survive if fire is kept out, but no forest, regardless of how careful logging may be done, can stand the ordeal of a fire without great damage.

The remaining virgin pine stands in Minnesota are mostly rather open, permitting young trees of the species to grow quite freely under the existing crown cover. This condition was observed in widely separated regions, Red Lake, Cass Lake, Pelican Lake, and in other localities. A representative forty-acre tract laid out to include as much pine as possible cruised 460,000 feet of timber, or about 12,000 feet per acre. This is a fair average for much of the pine timber in northern Minnescota. On this "forty" and everywhere in the region of Orr an abundant reproduction of pine is found in the virgin stands. The young trees are all of small size, either in the seedling or small sapling stage of growth. The stock appears healthy and has made excellent growth in the past few years. Representative sample acres upon which seedling counts were made show astonishing results. Careful counts of the young trees on plots one rod square revealed frequently fifty to sixty red and white pines. Even on areas of dense hazel and birch, pine reproduction was found in gratifying amounts. Only the very densest of hazel, birch, and maple showed up poorly in the tests. The young pines on these areas were scattering and usually showed signs of the great struggle they were waging for existence. Practically the same conditions obtain in the virgin pine stands in the vicinity of Cass Lake. Large areas of mature pine in this region have understories of young trees growing in sufficient quantity to fully restock the land. About Red Lake these conditions are even more pronounced.

The results of seedlings counts on ten representative plots one rod square and accompanying data are set forth below:

Plot No. 1.—Located on the flat top of a knoll in a mature stand of red and white pine. Sparse hazel, birch, brake, and vaccinium present. Density of brush and herbs, 3. Reproduction count revealed three red pines, thirty-five white pines, sixteen balsams, and one spruce.

Plot No. 2.—Northwest aspect, moderate slope in a stand of red and white pine, birch, spruce, balsam, and aspen. Underbrush similar to

above; density, 5. The reproduction count showed eight white pines and twelve balsams.

Plot No. 3.—West aspect, moderate slope in a stand of balsam, spruce, birch, poplar, and a few scattering red and white pines. Underbrush density, six; vine maple and hazel. The count showed one white pine and fifty-three young balsams.

Plot No. 4.—Level, in a stand of mature white and red pine, with a small amount of balsam and birch. Underbrush, alder, and hazel; density, 35. The count revealed thirty-six white pines and twenty-seven balsams.

Plot No. 5.—Very slight east aspect, in a stand of mature red and white pine. Brush, hazel, and alder; density, 4. Reproduction found; white pine, 76; red pine, 3; balsam, 17.

Plot No. 6.—Level, in a mature red and white pine stand. Brush hazel and alder, density, 3. Count showed forty-seven white pines, three red pines, and fifteen balsams.

Plot No. 7.—Southeast exposure, 20 per cent slope in a stand of large red and white pine timber. Brush, alder, hazel, and red maple; density, 4. The number of young white pines found was fifty; red pines, fourteen, and balsam, twenty-three.

Plot No. 8.—Practically level, in a stand of mature and overmature red and white pine. Birch, alder, and hazel brush were present to the extent of 0.2 density. There were eighty white pine, twenty red pine, and eleven balsam seedlings on the plot.

Plot No. 9.—Southeast aspect, 20 per cent slope in a stand of mature red and white pine. Alder, poplar, and birch form a ground cover to a density of 0.25. The seedlings found on the plot numbered forty-nine white pine, four red pine, and seven balsam.

Plot No. 10.—East exposure, rather steep, in a stand of mature red and white pine, having a brush cover consisting of hazel, vine maple, and birch of a density of three. The plot contained ninety-nine white pines, four red pines, and sixteen balsams.

The virgin pine timber in Minnesota will be cut in the next few years. As may be seen from the results of the representative plot seedling counts, there are in many cases advance growth present in the forest sufficient to fully restock the land to valuable tree growth. Why cannot this reproduction be preserved, and the forest perpetuated? Under present methods of logging the cut-over lands become wastes, as barren and desolate as a desert. By using a few common sense precautions in logging and by keeping out fires, there will be no desolation

but rather a new forest ready to take the place of the old will be on hand as soon as the old timber has been cut and removed.

The greatest factor in the perpetuation of the remaining pine forests is the almost universal practice of winter logging with horses. The woods work begins with the coming of cold weather and by the time the main operations are in full swing the young trees are covered deeply and safely under a heavy mantle of snow. The danger of destroying the reproduction in logging is reduced to the minimum. Topping and piling of brush are essential to reduce the fire danger. At the proper time the piles may be burned but care must be taken to see that the fires do not spread. Burning of logging debris is not necessary on areas which will be rigidly protected after logging.

The feasibility of perpetuating the pine forests as stated above can be readily established. The principal obstacle to the success of the plan lies in the ownership of the land. Lumber companies are not greatly concerned over the future of the forests on logged-off lands. Such tracts are sold to settlers or are held for speculation, and with the passing years are burned over repeatedly until every trace of the original forest has vanished. Unburned logged-off pine land has great possibilities as a producer of wood, and should be cared for and protected by the state or private enterprise for the benefit of the generations yet to come.

THE LAKE VADNAIS PLANTATIONS, ST. PAUL, MINNESOTA.[1]

By J. H. Allison,

Professor of Forestry, University of Minnesota.

The Lake Vadnais planting project has been carried on co-operatively by the Division of Forestry of the University of Minnesota and the Water Department of the City of St. Paul, which owns several hundred acres of land around Lake Vadnais, one of the sources of the city's water supply. This lake is about 1½ miles long by one-quarter mile wide. It is located about 7 miles north of the City Hall, in the hardwood belt of Minnesota; about 20 miles south of the southern limit of natural stands of white pine; and still farther away from natural stands of jack or Norway pines.

The surface of the land surrounding the lake is rolling, with a relative altitude of from 10 to 40 feet. The soil is of glacial origin. That to the east of the lake is a "Miami fine sandy loam" with a clay loam subsoil which Dr. Alway of the Division of Soils says is "decidedly productive" from an agricultural point of view. That to the west of the lake is a "Hinckley fine sand" with a sand subsoil, which Dr. Alway says is "very droughty" and "the lowest in productivity of any mineral soil in the country." Plantations have been established upon both of these soils. Both of them have been, or still are, occupied by open stands of red, burr and scarlet oaks. The better soil is well sodded except under the dense stands of oak where the sod is replaced by a luxurious growth of weeds. The poorer one (the Hinckley sand) carries a rather heavy growth of weeds, but is not sodded.

This project was initiated in the spring of 1914 as a result of a talk upon forestry given by Prof. Cheyney before the St. Paul Society of Civil Engineers. The superintendent of the water department, Mr. House, was present at that meeting. He immediately manifested an active interest in the possibility of converting the Water Department's

[1] Extract from an article read before the Forestry Section of the American Association for the Advancement of Science, Dec. 28, 1921.

idle lands at Lake Vadnais into a forest. As a result of a conference held a few days later between Mr. House and Prof. Cheyney, Prof. Wentling and myself, it was decided to plant about 10,000 trees (equivalent to about ten acres of land) that spring and I was authorized to act as advisor to the Water Department with reference to the carrying out of this and any future planting operations. The species selected at the conference for that year's operation were white pine and white and Norway spruce—because planting stock of these species was available at a local commercial nursery. Since 1914 a total area of about 140 acres has been planted.

Climatically this region is characterized by moist, cloudy springs; hot (having maximum temperatures of between 90 and 100 degrees F. during hot spells) but moderately moist summers; dry, cool falls; and long, cold winters (with extreme minimum temperatures of —20 to —40 degrees F.). The ground freezes very deeply, partly because snow, in quantity, usually does not come until January. Severe droughts, accompanied by hot weather, occur quite frequently in either summer or fall. Such droughts covered the months of July and August, 1916; October, November and December in 1917; September in 1918; August, September and October in 1919; and July, August and September in 1920. During nearly every spring there occur one or more days with very high (40 to 50 miles per hour) dry, southwestern winds. One or more of these dry, windy days have occurred each year during the time planting operations were being carried on, except in 1914. However, such days have had no measurable effect on the survival of the trees planted on them, probably because the severe conditions lasted only a few hours. The summer and fall droughts, however, have caused serious losses to plantations established during the preceding spring.

The primary object of this planting operation has been, and will continue to be, the establishment of a municipal forest, the only one I know of in the upper Mississippi valley. Coniferous species, known or believed to be suited to local climatic and soil conditions, have been mainly used. The cost of the work has been kept within limits defendable from a forest management point of view.

The secondary object of this operation has been, and will be, the obtaining of as much information as possible on the management possibilities of the various species which can be used under local climatic conditions upon the two types of soil found upon this tract. The data

collected, covering the reactions of the species used to local climatic-soil-cover conditions, will be of great value in ultimately determining the timber producing capacity of the two soils represented, more particularly that of the poorer one, of which there is a considerable local area.

My own plans for testing the different species have partially miscarried several times during the progress of the work, either because I could not get the planting stock I wished or because of errors on the part of the foreman in carrying out the planting instructions.

The following results can be reported for such plantations as are now five or more years old.

A—*Miami fine sandy loam.*—Clay loam subsoil. "A decidedly productive soil." (Dr. Alway). It has a "moisture equivalent" of 15.8 per cent for the first foot, 14.3 per cent for the second foot, and 14.4 per cent for the third foot for the area included in the sample plots).

Species Used.—White pine, Scotch pine and Norway spruce. In addition, some Colorado blue and eastern red spruces and balsam firs were planted experimentally.

Survival Table in the Open Field.

Species	Stock	Planted	At the end of—				
			First year	Second year	Third year	Fourth year	Fifth year
			Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
White pine..........	2–1	1915	88.3	74.7	64.0	....	61.3
Norway spruce.......	6″–8″	1915	88.4	70.1	55.3	....	45.8
Scotch pine..........	6″–8″	1916	83.0	....	....	....	82.0

The white pine and Norway spruce are planted in alternate rows in a field which was planted to corn in 1914. The Scotch pine is in an adjacent field that was in corn in 1915. The summer following the planting of the white pine and Norway spruce was a normal one with reference to temperature and rainfall, but the summer following the planting of the Scotch pine was very dry and hot, the July-August rainfall amounting to only 37.7 per cent of the normal for those months.

Height figures were secured from and are reported for a stand of white pine planted in the sod under an open stand of oak adjacent to the white pine-Norway spruce plot planted in the field in order that

Growth in Height (Inches).

Species	Stock	Planted	For 5 years			For last year of 5		
			Min.	Max.	Ave.	Min.	Max.	Ave.
White pine								
In field	2–1	1915	7	70	32.9	1	28	11.9
In sod	2–1	1915	6	41	19.5	2	15	6.4
Norway spruce								
In field	6″–8″	1915	7	45	24.3	3	19	8.2
Scotch pine								
In field	6″–8″	1916	19	85	47.7	2	27	15.0

the height growth of the pine upon the same quality of soil, but under different cover conditions, could be compared. The original sod plots for the white pine-Norway spruce were destroyed by fire in 1918 (at the end of three years).

B—*Hinckley fine sand.*—Sand subsoil. Dr. Alway classes this soil as being very subject to drought and of the lowest productivity of any mineral soil in the county. It has a "moisture equivalent" of 6.5 per cent for the first foot, 4.2 per cent for the second foot, and 3.0 per cent for the third foot.

Survival Table.

Species	Stock	Planted	At the end of—				
			First year	Second year	Third year	Fourth year	Fifth year
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
White pine	6″–8″	1914	90.2	86.9	....	Destroyed	
White spruce	6″–8″	1914	40.3	40.0	....	38.4	37.4
Norway spruce	6″–8″	1914	59.7	....	....	54.9	53.3
Norway spruce and white spruce mixed	6″–8″	1914	74.4	67.5	....	56.0	58.2

The white pine alternated, in the row, with the spruces where they were used separately from each other, and, as far as it would go, with them where used together. The mixed stand of spruce is located on land that is slightly better than that upon which the pure stand of spruces are planted.

At the end of three years, just before it was destroyed by order of the State Entomologist (the stock having been secured from a nursery

Growth in Height (Inches).

Species	Stock	Planted	For 5 years			Fifth year of 5-year period		
			Min.	Max.	Ave.	Min.	Max.	Ave.
White spruce	6″–8″	1914	4	24	11.9	....	....	4.3
Norway spruce	6″–8″	1914	5	26	13.5	....	....	3.9
Mixed								
White spruce	6″–8″	1914	9	40	16.5	....	....	4.2
Norway spruce	6″–8″	1914	11	33	16.0	....	....	4.5

later found to be infected with blister rust), the white pine was much taller and growing much more vigorously than either of the spruces. The planting of these plots was followed by two summers of approximately normal rainfall and temperature.

SUMMARY AT THE END OF FIVE YEARS

A—On the "decidedly productive" soil (Miami fine sandy loam). *White pine* (2-1 stock) vs. *Norway spruce* (6″-8″ stock). The percentage of survival of white pine is about a third larger than that of the Norway spruce. The average growth in height of the white pine is about one-fourth greater than that of the Norway spruce. At the end of each of the first three winters, the Norway spruce showed a considerable amount of frost (or drought) injury—the needles and often the buds being killed back for some distance from the tips of the main stem and of the branches. During the last two years, they have shown no appreciable amount of this form of injury.

Scotch pine (6″-8″ stock) vs. *white pine* and *Norway spruce* covered in the preceding paragraph. The survival percentage of the Scotch pine is very much higher than that of either the white pine or the Norway spruce, in spite of the fact that the summer following the planting of the Scotch pine was a very hard one on newly planted trees. For the same age and upon almost exactly similar sites, the average height of the white pine is two-thirds, and that of the Norway spruce one-half that of the Scotch pine.

White pine in the field vs. *white pine* in the sod, under an open stand of oak. In the sod, the white pine was planted in slit-like holes made with a grub hoe. While I have no counts to verify my estimate the percentage of survival of the white pine planted in the sod appears to be greater than that of the white pine planted in the field. On the other hand, the white pine in the sod, partially shaded,

growing in height only about half as fast as the white pine in the field.

B—On the very droughty sand—a soil of low productivity (Hinckley fine sand).

White spruce vs. *Norway spruce* (both 6″-8″ stock). The percentage of survival of the Norway spruce is considerably greater than that of the white spruce. The growth in height of the two species has been about the same so far. The Norway spruce was badly injured by frost (drought) during the first four winters. The white spruce showed no such injury.

White pine vs. the *spruce* (estimate). At the end of two years the percentage survival of the white pine was much higher than that of the spruces. Also it was growing much more rapidly and vigorously than either of them.

C—*Norway spruce* on the good soil (Maimi fine sandy loam) vs. the same species on the poor soil (Hinckley fine sand). The percentage of survival on the poor soil is somewhat greater than on the good soil, but the growth in height is nearly half greater on the good soil than on the poor.

D—Trial species on the good soil.

Colorado blue spruce. Planted in furrows ploughed in the sod under a moderately dense stand of oak. About 40 per cent of the trees were living at the end of five years. Those that have survived are thrifty, but are growing very slowly. This species, as planted in the city parks, is doing well.

Eastern red spruce. Planted in the sod, without ploughing furrows, under a moderately dense stand of oak. *A failure*. About 10 per cent of the original stand was alive at the end of five years.

Balsam fir. Planted in the sod, partly in furrows, partly directly in the sod, under a moderately dense stand of oak. Also a failure. About 31 per cent of the original stand was alive at the end of five years, and of this percentage at least half were in bad shape.

E—Other species that are being tried out. None of these plantations have reached (1921) five years of age.

(*a*) On the good soil. Norway pine and (accidentally) some jack pine.

(*b*) On the poor soil. Norway, jack, white and Scotch (Riga variety) pines. Of these species, jack pine is making much the most vigorous growth, many individuals, in a four-year-old plantation exceeding 60 inches in height.

F—The percentage of trees surviving on these plots, except the Scotch pine one, seems abnormally low. All of the work has been done under the direction of the same foreman and by the same gang of laborers. Several of these men have become quite seriously interested in the survival of the trees they plant. Perhaps the low percentage of survival is due to the combination of rather unfavorable climatic and ground cover conditions. The ground is covered by a heavy sod or a dense growth of weeds which can, during the first few years, take needed water away from the little trees. Since 1915 this region has been passing through a dry period. The mean annual precipitation for the Minneapolis station of the Weather Bureau is given as 29.31 inches. Not since 1915 has the precipitation reached that amount, and during the last two years it has fallen to about 23.5 inches a year. This dry condition also holds true for the growing season (May to September inclusive) totals, the mean precipitation for the season being 19.09 inches and that since 1915 ranging from 15.3 (1920) to 17.2 (1918) inches.

In closing, I wish to say that both Mr. House's successors in the office of Superintendent of the Water Works have taken an active, personal interest in this project. Both he and they have been willing to spend more money on the undertaking than I was willing to recommend, considering the prospective returns. Neither have the losses (18 acres of new plantation by drought in 1916, five acres by order of the State Nursery Inspector because of possible infection with the white pine blister rust in 1917, and ten acres by fire started by a county road gang working alongside of the plantations in 1918) caused them to hesitate or become discouraged.

REVIEWS

American Forest Regulation. By Theodore Salisbury Woolsey, Jr. New Haven, Conn. The Tuttle, Morehouse & Taylor Co. 1922. Pp. 217.

This is a book of major importance which deserves a more detailed review than is possible in the brief time before going to press with the May issue. But pending the preparation of such a thorough analysis, brief mention of the contents and general character of Woolsey's latest work will be timely and will direct attention to a new text on forest regulation.

The book is in two parts and thirteen chapters, besides an appendix. Part One, called "Policy and Theory of Regulation," contains ten chapters, headed as follows: I, Introduction to Forest Regulation; II, Background of a Regulation Policy and Sustained Yield; III, Management and Administrative Subdivisions; IV, Rotations—Technical, Silvicultural and Economic; V, Financial Rotations; VI, The Normal Forest; VII, Regulating the Cut; VIII, Volume Methods of Regulation; IX, Area and Area-Volume Methods of Regulation.

Part Two, written by Prof. H. H. Chapman, has the following chapter heads: X, The Cutting Cycle as a Determining Influence in American Forest Regulation; XI, The Application of Regulation to American Forests; XII, The Problem of Sustained Yield; and XIII, Regulation of Forests Composed of Even-aged Stands. Each chapter ends with a quiz which enhances the usefulness of the text for purposes of instruction.

The outstanding feature of the appendix is a translation, from Martin, of Forest Management in nine European States.

Although this is not a critical review, but only a book notice, it should be stated that the general impression created by Woolsey's work is distinctly favorable. It shows painstaking study of an intricate subject and a wealth of detail that will make it valuable to both student and teacher. It is by far the most ambitious text in English on the subject of forest regulation and is particularly timely because of the interest in working plans as an integral part of any national forest policy. As Dr. Fernow says in his introductory note: "The effort of investigating the applicability of European methods and of developing American methods, as attempted in this volume, is one which is worthy of all praise."

It is understood that the author was also his own publisher and that copies of the book may be obtained directly from him at 242 Prospect Street, New Haven, Conn.

A. B. R.

Note.—Detailed review will appear in the fall.

PERIODICAL LITERATURE

SILVICULTURE, PROTECTION, AND EXTENSION.

Timber Production

The author discusses the question whether the much maligned high forest management utilizes all factors at its command to satisfy the physiological demands of the forest or whether, in this respect, there are obstacles to be removed whose removal will establish the value of this system in the eyes of foresters. Especial reference is made to the pine forests in the comparatively dry region of northeast Germany; in those of northwestern Germany the real problem concerns pan formation in the soil. One reason for the numerous failures in pure pine seedling forests is the use of poor seed, especially on private forests. The main criticism concerning the seed is directed to its unknown origin rather than to the substitution of mountain pine for Scotch pine. In general, the problem is one of deterioration of soil under old forests and increased deterioration following clear-cutting and exposure of the soil.

Unlike conditions in the humid territory of upper Silesia, where the fight must be directed against too much water and weeds, the question involves a fight for water. In this connection, the forest industry has much to learn from agriculture and is itself to blame for failure to make use of and to apply simple physiological facts. A study of moisture conditions and fall plowing might solve the problem of pine culture on light sandy soils. It is a well-known fact that spring plowing not only helps to dissipate the moisture stored during the winter but disturbs bacterial activity which to a certain extent prepares the more soluble salts needed by plants in the upper soil. Raw humus is the greatest water dissipator, and on clear-cut areas it becomes so dry as to become almost impervious to water penetration. As a result, the upper soil is reduced to a point of physiological dryness where no available water is left. Excepting under extraordinary conditions the lower soil retains enough moisture so that the deeply penetrating roots can supply the tree with enough moisture to preserve life. However, the salts and nourishing materials necessary to sustain growth which the tree secured from the upper soil are no longer obtainable; height

growth is interfered with and the top usually dies back. This condition, which is often met with in oak stands with spruce understory, makes impossible the production of lumber, which presupposes straight growth.

Any factors, on the other hand, such as straw (humus) collection and lying open under clear cutting which decrease the humus content of fine sandy soils and the water holding capacity, produce unfavorable conditions for forest growth. Foresters usually have attributed the dying back of stands to hard-pan formation without considering that the conditions necessary for its formation were totally lacking. The question then concerns the medium which foresters have on hand to balance water supply and consumption on pure sandy soils. In 1909 the author experimented in the forest district of Schwentin by plowing up all of the soil (not in strips) on a clear-cut area after the stumps had been removed. The plowing ranged in depth from 15 to 18 cm. and pine seedlings were planted the following spring. The resultant plantation was decidedly thrifty and showed no loss from the common needle-shedding disease. The ground cover which usually consists of heather, was characterized by broad-leaf grasses, a striking proof of physical and chemical betterment. In this way the humus was made beneficial to the young plants since it helped the soil to retain the moisture and by aeration helped bacterial activity in the soil. In nurseries, of course, where special soil preparation is required, this process is not desirable; and is also not practicable on rocky soils.

In state forests, where a high rotation is practiced and the high forests are very open because of the removal of diseased trees, and the stumps are not removed after felling, conditions are more serious but, nevertheless, the method is practicable. In an experiment in such a 120-140 year old stand, the soil in the fall was completely plowed for planting and plowed and rolled for sowing. Drill sowing was done—broadcast strip sowing not being practicable. The cost of the operation is no cause for discouragement because of the general success of the sowing and planting and also because of the fact that the needle humus of the young trees is made immediately available instead of being caught by the heather. Furthermore, fire protection becomes less a problem because the dry humus cover is removed. Where the humus is very heavy it is even advisable to burn the humus and proof of this is found in the pine regeneration on burned over areas in the neighborhood of old collieries. The value of plowing might justify the grubbing of stumps.

On soils of higher water and mineral content the thorough plowing system is not necessary. The problem here is to produce a dense stand from seed, since the trees develop side branches and density of stand is an economical desirability. The heavy soil cover is best combatted by means of a hoe and seeding by drilling is best. As to the desirability of sowing versus plantations, many different views are held. The sowing enthusiasts claim their method is conformable to nature; but how this is possible under the very artificial conditions of the clear-cut high forest, it is hard to understand. Sowing very often produces a density which the soil cannot sustain, or which will produce complete stagnation in the resultant stand. On the other hand, Hallimasch is severe in plantations.

The author compares the different conditions existing in the natural (selection) forest and in the high forest. In a few words, the difference between the two is a change from shade to light (less competition, greater proportion of crown to shaft, etc.) in the former and a change from light to shade (severe competition, etc.) in the latter. The natural forest, in itself, automatically protects itself against an overabundance of trees; while in the cultural forest, nature must be assisted by culture to attain the same results.

In deciding between sowing and planting, the amount of future labor necessary must be considered. The success of sowing depends upon the depth at which the seeds are sown. Shallow sowing on ordinary "pine" soils is a false practice and the seeds should be sown as deeply as possible, say under a layer of 1.5 cms. of light sand. This can only be done by means of a drill machine, which offers the other advantage of saving seed. It cannot be used on rocky soils, however, and on moist soils free of weeds, its use is not required.

The raising of nursery stock is a precarious and particular business, since the needle shedding disease is very prevalent. One of the causes leading to this disease is frost, and earth pockets subject to frost must be avoided for nurseries. Commercial nurserymen have shown that good pine stock can be produced on light sand soils by means of scientific water conduction during drought periods and by the scientific application of compost, which furnishes the bacteria for producing an uninterrupted supply of food material, chiefly nitrates. It is possible for the forester to provide for the application of compost, but the other, involving the conduction of water, is beyond the realms of practicability and the same result must be secured by skilful working of the soil and

the establishment of nurseries in sheltered localities; if possible under the protection of a stand of pines. Light sandy soils with a stand of birch are very unfavorable for pine nursery stock. The best sites are found in pole stands.

In as far as temporary versus permanent nurseries are concerned, there is no question in the author's mind for modern methods of fertilizing the soil can permanently keep the soil in good condition.

Although much thought and study has been put into solving the scientific methods of assisting nature in producing a high quality high forest, the practical end has not kept up with the theoretical end. It is a very important achievement to so direct the artificial forest by thinnings and cleanings that it may produce the same results secured from the natural forest. The technic of thinnings has established a few points definitely; thinnings cannot be started too early; they must follow each other as soon as possible; too rapid crown expansion must absolutely be avoided to insure continued health and rapid growth, and the thinning must be "liberal" in character. By means of proper thinnings, the much abused cultural forest can rank high as a producer of economic values.

The object of the management will govern the character of the thinning operation. On poor soils, the necessity of thinning for physiological reasons becomes especially important in order to secure the maximum of growth energy by regulating the number of stems on the ground. The question concerning the proper degree and rotation of thinnings gives rise to widely different answers but it will be noted, the problem concerns foresters more in theory than in practice. It has been a common practice to thin lightly in intolerant species to avoid exposing the soil; and often it is a mistake to keep a heavy crown cover. On good soils the protection of the soil should be secured by an understory.

It is impossible to keep the ill-famed blueberry from coming in on the ground under mature high forest stands, and the only remedy is complete plowing after clear-cutting. The blueberry will then not have to be regarded with misgiving; and if needs be, its crop can be harvested annually and thus become an actual producer instead of being regarded an enemy.

The author has endeavored to show that there are several means at hand to assist the much maligned high-forest management to a higher plane, and that those bad points can be remedied which now give it its

rather bad repute. Furthermore, it must not be overlooked that the coniferous high forest only enabled the forests to supply the necessary mine material during the war. By means of scientific principles and methods the system should be perfected rather than to experiment with the introduction of a more "natural" system. J. R.

Stephan. *Zur Streitfrage "Holzzucht in der Hochwaldbetriebsform mit Kahlschlagverjüngung."* Zeitschr. Forst.-u. Jagdw., 52: 497-523. 1920.

Concerning Mixed Stands

Although pure even aged forests, the result of man's attacks upon natural conditions, have several advantages, especially in as far as order and administration are concerned; they have disadvantages which are becoming more pronounced as our knowledge of them increases. Mixed stands require for their full development a view of the future ripened by experience which the present theoretical forester very seldom possesses. The natural advantages of mixtures are well-known; but those which may be derived in the form of wood products by skilful choice of species and management are more important. Poor success with mixtures in the past was due to improper choice of species of which the author gives a few examples, as hardwoods with spruce, which tends to grow in pure stands or convert mixtures into pure stands. Pine and spruce should not be mixed unless it is desired to reap the pine as an intermediate crop, or grow spruce as an understory.

The best all-around tree for mixtures is the beech, the ideal nurse. It not only acts as a nurse, but protects and enriches the soil and also protects its associate against outside enemies, insects, fire, etc. Failures of beech and oak mixtures have been due to a lack of knowledge of the requirements of the species necessary for mutual development; also to the continued preference of Q. pedunculata over Q. sessiliflora. When old thrifty oaks are found in beech stands they are invariably of the latter species. On the better soils of northeast Germany, an effort should be made to grow Q. sessiliflora with pine.

Of the conifers, larch is an ideal associate as an upper story for beech. The beech forces the larch to produce a clean bole and because it grows in close stands, removal of the larch leaves no openings in the crown cover. Spruce may be grown with beech but selfishly tends to crowd back its nurse by its wide branching habits. Because of its great intolerance, Q. pedunculata makes an extremely poor nurse; but the value of Q. sessiliflora will be appreciated as fully as that of the

beech in the future. Although the most ideal mixtures are secured where conditions favor both species alike, it is possible for the forester to assist one of the species by cultural means to overcome natural obstacles. This is especially true in carrying a mixture from one generation to another, for in some cases as with spruce, aggressiveness in seeding may tend to change a mixture to a more or less pure stand of one species. In passing on the other advantages of mixed stands, the ease of securing natural reproduction must not be overlooked. The silviculturist should adopt the following motto: regeneration under shelter and protection, and this can best be accomplished under mixed stands.

J. R.

Frömbling. *Über Mischbestände.* Zeitschr. Forst.-u. Jagdw., 52: 688-698. 1920.

STATISTICS AND HISTORY.

Contented Woodsmen

Competition during the war and after has forced upon the attention of Swiss foresters the means taken in other industries to increase the efficiency and contentment of employees.

Payment in money alone is the ideal toward which industry is tending but in woods work it is not yet even in sight. Free fuel or building material, the use of tools, and allowances for sharpening and repairing tools are perquisites so firmly entrenched by long usage that the worker will not willingly give them up. Their real money value, however, is difficult to estimate accurately.

In other ways, though, forestry must keep pace with changes in methods. This is particularly true with reference to better houses—convenient, sanitary, and well maintained—comfortable lunch shelters in the woods, and the encouragement of better feeding. Much education along the latter line is needed to prevent alcohol taking the place of more nourishing foods. Statistics in the forest district of Bern, covering the period from 1860 to 1918, show that woods workers have been subject to illness in the following proportions: Rheumatism, 17 per cent; colds, 17 per cent; digestive disturbances, 10 per cent; consumption, 8 per cent; miscellaneous, 48 per cent; total 100 per cent.

The author concludes with a recommendation to follow the Taylor system of scientific management in placing the burden of teaching ways and means and experimentation in new methods directly upon the management.

K. W. W.

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NOTES

Complete vs. Partial Utilization

The following comes from the Lake States:

One area was cut over from 1911 to 1918, a period of 7 years, and 21 Sections were cut. The company took from this area in board measure, mill scale, 179,163,702 feet, and the log scale for the same area was 172,157,880 feet, an average per Section of 8,531,605 feet board measure, or an average per Section of 8,197,994 feet log scale.

The same company cut an area in 1918 to 1922, a period of 4 years, of four Sections. This area was logged clean, brush piled, and everything taken from same from which sale of material could be secured. The mill scale board measure for this period was 71,000,000 feet; log scale 54,000,000 feet; average per Section board measure 17,750,000 feet; average per Section log scale 13,500,000 feet.

These figures do not look reasonable on the surface, but they are taken from actual scale reports and actual cutting area. The twenty-one Sections, however, were logged under the old method of leaving everything but the best. The four Sections were logged, taking everything clean.

These figures will give some idea of what material was conserved by close logging and what would be saved by clean cutting and planting. They will also show what could be saved to advantage by the majority of the lumber companies, provided there was a reasonable freight rate on the lower grades of material.

Further Comments on Professional Ethics

I have read with much interest Mr. Olmsted's paper on the above subject. It seems very timely that the matter should be opened for discussion.

Probably many of us are quite as much in the dark as Mr. Olmsted confesses himself to be. It is not easy at this comparatively early stage to lay out a definite line of cleavage between all of the duties which the dignified professional forester may or may not assume. Certain general activities do appear, however, which I feel might well be proscribed. Chief among these is the role of broker-forester, as Mr. Olmsted aptly puts it. A forest engineer may be A-1 in every respect; his field work and reports may be as conscientious and sound as it is possible to make them; he may be energetic, thorough, and of unassaila-

ble personal integrity—but indulgence in the selling of timber lands, I am convinced, is outside the realm of true professional activity. Does one need to go through a forest school to become a timber land broker or factor? Certainly not. I might substitute for Mr. Olmsted's simile of the physician the case of the practicing veterinary who furnishes carcasses to the glue factory.

The case of the consulting forester who handles the manufacture and marketing of forest products will probably furnish ground for considerable debate. Personally, I am as yet undecided on this although I feel lenient towards the man handling forest products which are the results of sound, applied forestry. Here, while the question of the forester's compensation promptly rears its head, it is, of course, possible to make financial arrangements wholly apart from any commission basis. This removes the possibility that the urge of personal income may exert an improper influence which might divert the forester from the best silvicultural practice.

Let us have more discussion of this whole subject. I feel strongly in favor of the Society's making the first attempts to establish a line of demarcation between professional and unprofessional activity.

HENRY H. TRYON.

A CORRECTION

EDITOR JOURNAL:

In the February issue of the JOURNAL there is an article by Woolsey, "Public Forestry on Private Land," in which he describes our reforestation law, and states that the original owners of lands purchased under this act can redeem their lots within ten years by reimbursing us for the purchase price plus moneys spent for improvements and maintenance at four per cent interest.

As a correction I will state that the four per cent applies only to the purchase price, and no interest is charged on the money spent in reforesting the land.

H. O. COOK,
Chief Forester, Department of Conservation, Boston, Mass.

TIMBER PRESERVATION IN THE UNITED STATES

According to a recent report of the Service Bureau of the American Wood-Preservers' Association over 2,400,000,000 board feet of timber

for various purposes were pressure treated in 1921 by the 122 wood preserving plants in operation throughout the United States, thereby surpassing the 1920 record by nearly 17 per cent. Approximately equal amounts were treated with coal-tar creosote and with zinc chloride, the standard wood preservatives. To treat this wood 51,375,-360 pounds of zinc chloride, with an absorption of one-half pound per cubic foot, and 79,384,326 gallons of creosote, with an absorption of 5 to over 20 pounds per cubic foot, were required. The material treated consisted mainly of construction timbers for wharf, bridge, highway, mining and building purposes, piling, telephone and power poles, ties, fence posts, wood blocks for street paving and for factory floors, and timber for miscellaneous uses.

The Adirondack Mountain Club, a new organization in New York State, was incorporated on April 26, 1922. Its purposes are similar to those of the Appalachian Mountain Club of New England and the Sierra Club of California. The club expects to issue publications and to further the use of the Adirondack Mountains by recreationists. The President is Geo. D. Pratt, former Conservation Commissioner. Col. H. S. Graves is chairman of the Committee on Conservation. Among the foresters in New York State active as charter members are A. B. Recknagel, W. G. Howard, C. R. Pettis, F. F. Moon, and Hugh P. Baker.

The Intercollegiate Association of Forestry Clubs held a three-day meeting at Syracuse, April 20-22, 1922, representatives of 15 forest school clubs being in attendance. The President Club for the past year was that of the N. Y. State College of Forestry at Syracuse University. Favorable action was taken on a proposal to admit as Associate members the Clubs of the Forest Schools of other countries. The Forestry Club of the University of Montana was chosen President Club for 1922-23.

In that Forstmeister Meister's book on the Sihlwald has in recent years been difficult to obtain, it may interest forest school librarians and others to know that a limited number of copies may still be had from Albert Müller, Sonnenquai 18, Zürich, Switzerland. The price is 12 francs (Swiss money). Müller was editor of the revised and augmented second edition, issued in 1903 shortly before Meister's

death. He alone controls what is left of the edition. The exact title of the volume is "Die Stadtwaldungen von Zürich."

On April 28, 1922, there was organized in Chicago the Illinois Forestry Association, with the special purposes of formulating "an adequate forestry policy for the State of Illinois and securing the same by legislative enactment," and of bringing about the establishment of a State Department of Forestry. The president and secretary are respectively, Prof. Henry C. Cowles, of the University of Chicago, and S. F. D. Meffley, Secretary of the Lumbermen's Association of Chicago.

At the annual meeting of the Woodlands Section of the American Paper and Pulp Association, held in New York City on April 11, 1922, C. W. Hurtubis, of the Hammermill Paper Company, Erie, Pa., was elected Chairman and O. M. Porter, Secretary-Treasurer. These officers, with E. A. Sterling, R. S. Kellogg, and O. E. Lauderburn, constitute the Executive Committee of the Woodlands Section for 1922.

William L. Hall is Secretary of the Central States Forestry League. An important meeting of this organization was held in Chicago in April, 1922, in connection with the nation-wide celebration of the Second Annual Forest Protection Week proclaimed by President Harding. The Central States Forestry League now comprises representatives of eight States.

For its summer meeting this year the Woodlands Section of the Canadian Pulp and Paper Association plans to visit the Adirondacks on an automobile trip during the second week of July. The especial object is to inspect the forest plantations and nurseries of the N. Y. State Conservation Commission and of the Delaware and Hudson Railway.

The Massachusetts Forestry Association is this summer running two personally conducted excursions to visit forests and to see forestry work. One traverses certain of the National Forests and National Parks in the Western States, as in former years. The other consists in a tour of the Scandinavian and other Northern European countries.

The Second National Conference on States Parks was held at Bear Mountain Inn, Palisades Interstate Park, New York, May 22-25, 1922. Two days were devoted to business sessions, the remainder of the time to trips of inspection in the Palisades Park and to other near-by points of interest.

The use of the airplane in forestry work is steadily increasing in Canada. During the summer of 1922, the Forestry Department of the Province of Ontario will make an aerial reconnaissance of its unexplored northern territory. The work is done under the direction of E. J. Zavitz, the Provincial Forester.

Another new State Forestry Association is that of Nebraska, organized in March, 1922, with T. W. McCullough as President and Mrs. J. G. Corrick, of Palisall, as Secretary. Its program is to stimulate forest planting and to bring an appreciation of what forestry means to the people of the State.

C. E. Lane-Poole, Conservator of Forests for Western Australia, has resigned his office and will go to Papria, New Guinea, to report on its forest resources. His successor is R. A. Gibson, formerly of the British India Forest Service.

Hon. Alexander Macdonald has been appointed Conservation Commissioner of the State of New York in place of Mr. Ellis J. Staley, resigned. Mr. Macdonald had previously, for some years, held the position of Deputy Commissioner.

C. T. Stagg, formerly Professor of Law at Cornell University, has been appointed Deputy Commissioner in the N. Y. State Conservation Commission. An important part of his duties will be to administer the recently enacted water power laws of that State.

Col. Henry S. Graves takes up on July 1, 1922, his duties as Dean of the School of Forestry at Yale University. It is understood that Professor Toumey expects from now on to devote much of his time to research.

The Dominion Forestry Branch expects to replace a part of its ground patrol by the use of five airplanes, each with a carrying capacity of seven men and pilot. This work is under the direction of Col. Stevenson, District Inspector of Forest Reserves.

R. Y. Stuart was appointed in April as Forestry Commissioner of Pennsylvania to succeed Hon. Gifford Pinchot, who resigned to devote himself exclusively to his campaign for the Governorship of the State.

British Columbia will use seaplanes in its fire protection work this season. Experiments are to be tried of transporting expert fire fighters from one fire to another.

T. S. Woolsey, Jr., author of "Studies in French Forestry," will appreciate having members of the profession write him of any errors they have detected in reading this book.

The American Scandinavian Foundation is conducting this summer a "students tour" to Norway, Sweden and Denmark, in which visits to forests has some part.

Dr. Joseph Trimble Rothrock

DIED JUNE 2' 1922

The Society adopted the following resolution upon the death of Dr. Joseph Trimble Rothrock, an Honorary Member of the Society of American Foresters:

The death of Dr. Rothrock has brought to every friend of forestry a sense of personal as well as professional loss. He was one of the great leaders of the forest movement and his many achievements will constitute an enduring monument to his name. Few men, however, have in so conspicuous a degree commanded the universal personal regard and affection of his associates. This was due to the underlying motive of his work that was always directed to an humanitarian purpose. He was respected for his intellectual power and his actual accomplishments; he was loved because he loved mankind; men worked for him because he worked for them; he was followed because his leadership was in the interest of others.

Throughout his career Dr. Rothrock worked and fought for his ideals. In the Civil War he was in the front ranks as a captain of cavalry, performing valiant service for the country. Though trained as a surgeon, he had a broader interest in science, achieving a wide reputation as a botanist. Soon after the war he joined an expedition of exploration in British Columbia and Alaska, and in 1873 served as botanist and surgeon on the United States Geographic and Geological Surveys in the West. Soon afterwards he was called to a chair of botany in the University of Pennsylvania, and it was during this sixteen years' service with that institution that he laid the foundation for forestry in Pennsylvania.

It was in 1870 that a fund left by Michaux in 1855 became available for a lectureship in the American Philosophical Society of Philadelphia, designed "to advance the progress of agriculture with reference to the propagation of useful forest trees." For twenty years the fund

remained unused. Dr. Rothrock was made the first Michaux lecturer and through this means he was able to teach the people of the State the significance of forestry.

Undismayed by public indifference and opposition, he persevered in his teaching. He set forth the economic need of forestry, but he constantly dwelt upon the human service rendered by the existence of well managed forests. He early developed the idea of using the eastern mountains in the cure of tuberculosis, and he made public health one of the objectives in the establishment of public reservations. That he demonstrated this theory and secured a great system of public forests for the State that could be used for this as well as other public benefits gave him greater satisfaction than any of his other achievements.

The history of forestry in Pennsylvania centers about Dr. Rothrock. The present great system of State forestry rests upon his devoted service. It was his educational work that led to the establishment of the State Forest Commission in 1891. He was the first Commissioner of Forestry and, though he resigned from this position in 1904, he remained a member of the Commission until shortly before his death, and through these years was the guiding spirit in forestry in the State. Dr. Rothrock's influence, however, extended far beyond the limits of his State. He was a powerful figure in the national forest movement and of great influence up to the time of his death.

We have lost a great teacher, whose life has been an inspiration to all of us. Deeply we mourn his death. His spirit of public service, his courage and perseverance, his ideals of advancing the welfare of his fellow men will remain to stimulate the efforts of those of us who continue his work. In this we express the deep feelings of the entire membership of the Society of American Foresters.

With hearts full of grateful memories of a leader and friend, we extend our deep sympathy to the members of his family who survive him.

HENRY S. GRAVES,
FILIBERT ROTH,
R. Y. STUART,
Committee of the Society of American Foresters.

Representative on Committee for Standardization of Cross-Ties

At the request of the American Engineering Standards Committee, the United States Forest Service and the American Railway Engineering Association, acting as joint sponsors, have organized a sectional committee to undertake the task of harmonizing existing specifications for wooden cross-ties and switch-ties, with the object of developing uniform general specifications. The organizations which have been invited to name representatives on the Sectional Committee are: American Electric Railway Association, American Railway Engineering Association, American Mining Congress, American Society of Civil Engineers, American Society for Testing Materials, American Wood-Preservers' Association, National Association of Railroad Tie Producers, National Hardwood Lumber Association, National Lumber Manufacturers' Association, Society of American Foresters, U. S. Department of Commerce, U. S. Forest Service.

J. R. Coolidge, III, has been named by President Sherman as the Society's representative on this Committee.

Representative of Committee for Standardizing Methods of Testing Wood

The American Engineering Standards Committee has designated the American Society for Testing Materials and the United States Forest Service as joint sponsors to organize a Sectional Committee for the purpose of developing uniform standards in the methods of testing wood. The following organizations have been asked to name representatives on this Committee: American Railway Association, American Railway Engineering Association, American Society of Civil Engineers, American Institute of Architects, American Electric Railway Association, American Society of Mechanical Engineers, American Hardwood Manufacturers' Association, National Lumber Manufacturers' Association, National Hardwood Lumber Association, National Association of Farm Equipment Manufacturers, Society of American Foresters, Society of Naval Architects and Marine Engineers, Society of Automotive Engineers, Association of Wood-Using Industries, Aircraft Manufacturers' Association, U. S. Department of Commerce (Bureau of Standards), U. S. Navy Department, U. S. War Department, American Society for Testing Materials, U. S. Forest Service.

Professor George R. Green, of Pennsylvania State College, has been

designated as the representative of the Society of American Foresters on this Sectional Committee.

Membership

The following have resigned membership in the Society, effective January 1, 1922: Senior Member, Forman T. McLean; Member, Paul C. Kitchin.

The following have been dropped from membership, in accordance with Article X, Section 3, of the Constitution: Senior Members—Shirley W. Allen, Herbert Graff, Richard A. Hamilton, Harold G. Spahr, Edmund J. Zavitz; Member, John C. Ketridge.

The following have declined to accept election to the Society: Senior Member—M. N. Stickney, elected November 26, 1921. Members—W. G. Conklin, elected November 26, 1921; H. W. Harris, elected January 12, 1921; P. R. Hicks, elected July 1, 1921; E. F. Smith, elected March 23, 1922.

The following men have neither accepted nor declined election, and therefore have been dropped from the rolls: Senior Members—J. V. Wulff, elected October 29, 1919; Robert R. Neefe, elected November 26, 1921. Members—R. H. Charlton, elected October 29, 1919; C. B. Baker, elected March, 1920; R. H. Parsons, elected March, 1920; Frank E. Andrews, elected January 12, 1921; F. V. Horton, elected October 27, 1921; H. H. Richmond, elected October 16, 1919.

W. N. Sparhawk,
Secretary.

ERRATA

In the March issue of the JOURANL, Vol. XX, No. 3, the following changes should be made in the article, "Humus and Root Systems in Certain Northeastern Forests":

Page 234, next to last line from bottom—"usual" instead of "unusual".

Page 250, line 17, "maintained" instead of "estimated".

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